WATER WORKS & SEWERAGE

A GILLETTE PUBLICATION

L. H. Enslow EDITOR

MARCH, 1937
VOLUME 84. No. 3

IN BRISTOL

"THE TWIN CITY"

Nestled in a valley between the Cumberland and Blue Ridge Mountains and located squarely on the State Line between Virginia and Tennessee, Bristol, although one community, is in reality a two-state city. While its civic organizations have but one body, it has two mayors, two city councils, two chiefs of police—in fact, a "pair" of all political officials. Elevated 1,700 feet above sea level and having an average temperature of 61 degrees, Bristol's slogan is "A Good Place To Live."

Bristol is a progressive industrial city. One of the largest overall factories in the world is located here. Other industries produce lumber products, paper, hosiery, women's clothing, trailers and mine cars. In the beautiful surrounding country the chief agricultural products are tobacco, corn, wheat, dairy, poultry and produce from general farming.

Both City Water Departments are users of Pittsburgh Water Meters, Bristol, Tennessee, having purchased 3,000 in 1936.

PITTSBURGH EQUITABLE METER CO.
MERCO NORDSTROM VALVE CO.
MAIN OFFICES PITTSBURGH, PA.

NEW YORK · LOS ANGELES · TULSA · HOUSTON · MEMPHIS · BUFFALO
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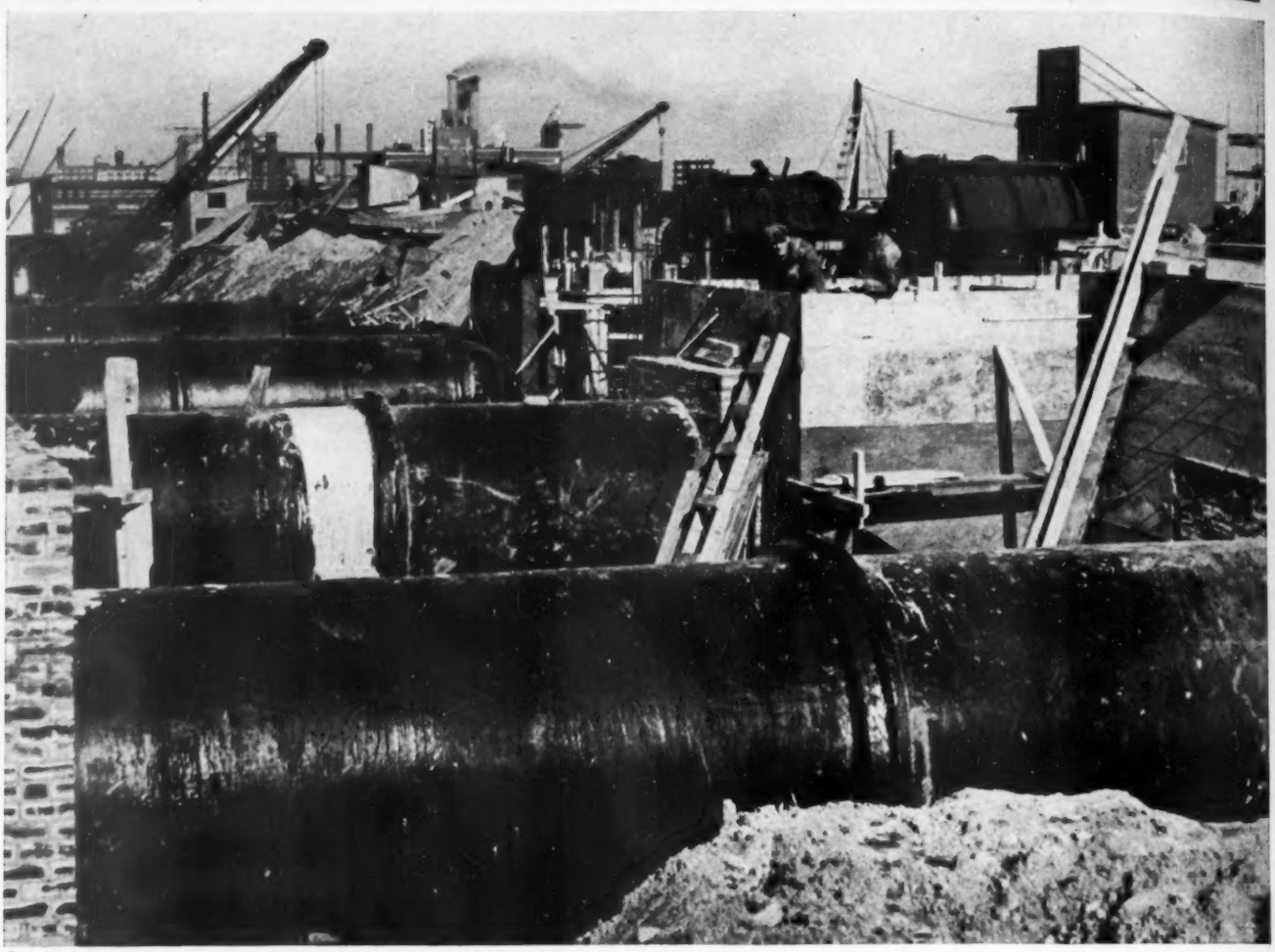
PITTSBURGH WATER METER

WATCH THE TREND TO CAST IRON



Installing U. S. Cast Iron Pipe—Extension to Ward's Island Sewage Disposal Plant, New York City

As a result of previous strict adherence to an exacting delivery schedule, U. S. Cast Iron Pipe is again used for the extension to New York City's already prodigious disposal plant at Ward's Island. We have exceptional facilities for production and prompt shipment of large and small diameter pipe, complicated fittings and special castings for disposal and treatment plants. Sales of U. S. Cast Iron Pipe for sanitary sewer lines are the largest in our history. We ship from 15 plants and storage yards throughout the country.

UNITED STATES PIPE AND FOUNDRY COMPANY
BURLINGTON NEW JERSEY

Foundries and Sales Offices throughout the United States

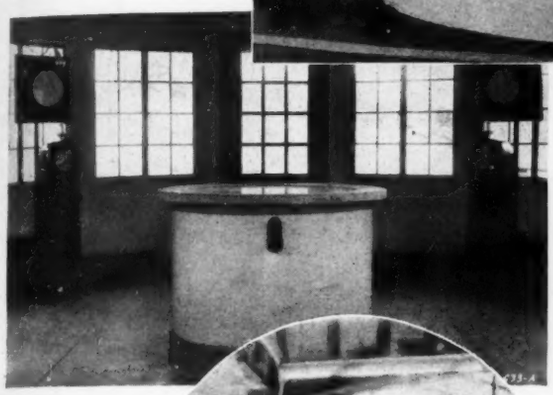
U. S. CAST IRON PIPE

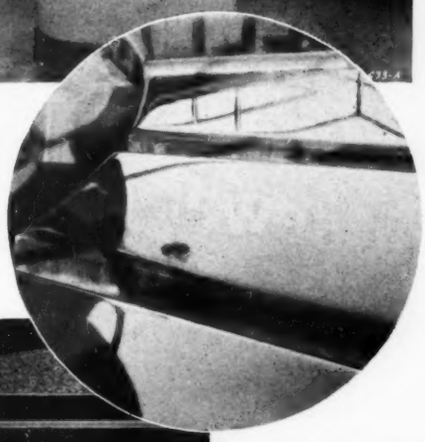
for sewers and sewage treatment plants

The MORSE ALL-STEEL FILTER PLANT

(Right) A pair of Morse Filter Plant Units. Each is 100 ft. dia. overall and has a capacity of 5 m.g.d.

(Below) Interior of filter control house at top and center of unit.





(Right) Washing period. The washwater is being carried off in radial troughs.

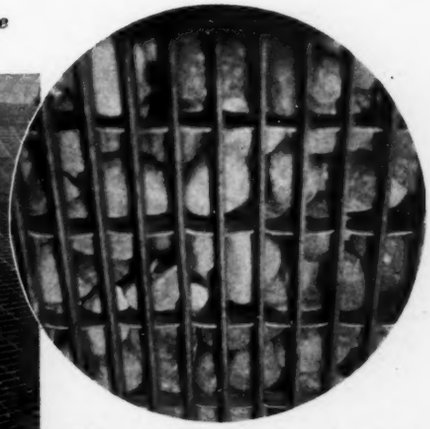
ADVANTAGES:

1. **All-steel construction offers the same advantages that have proved so desirable in large capacity water storage tanks. No seepage, no cracking, less maintenance expense.**
2. **Thirty to 40 per cent lower in first cost with all things being equal. Also requires less ground space per unit of capacity than any other type of construction.**
3. **Modern. Definitely designed to push obsolescence as far into the future as possible.**
4. **Flexible in both operation and application. Put in capacity needed at present; add more capacity easily and economically at any time in future.**
5. **Lower operating costs. Very small loss of head through plant means less pumping cost. Cleaning and maintenance is easier and quicker.**

The uniformly satisfactory results obtainable with Morse Filter Plants have been amply proven. Let us show you the record. Address our nearest office.

(Above) A section of the filter bed showing wash trough.

(Below) This steel grating supports the rapid sand type filter bed.



(Above) Looking up through grating under filter bed.

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Chicago.....2198 Old Colony Bldg.	Dallas.1479 Dallas Athletic Club Bldg.	Houston.....2919 Main St.	Boston.1548 Consolidated Gas Bldg.
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Fabricating plants in CHICAGO, BIRMINGHAM, and GREENVILLE, PA.

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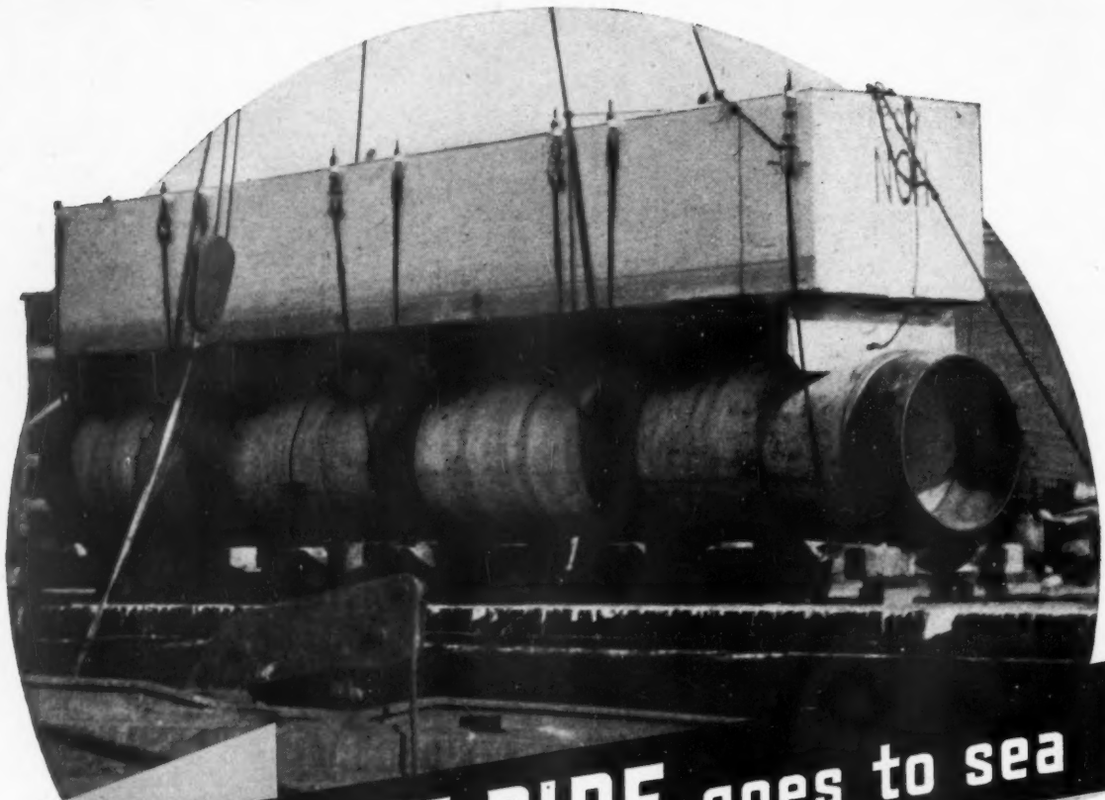


CONCRETE PIPE goes to sea in a half-million dollar sewer project

Four 12-ft. sections of 60-in. reinforced concrete pipe being towed into the Pacific Ocean and lowered into position. The County Sanitation District of Los Angeles County. A. K. Warren, chief engineer, and A. M. Rawn, assistant chief engineer.

THINK of a sewer 60 in. in diameter and 5,000 ft. long that discharges 110 ft. under the surface of the ocean. That summarizes the project now under construction by the Sanitation District of Los Angeles County. It is one of the most difficult pipe line undertakings of record.

For 2000 ft. off shore, the line is built with 18-ft. sections laid in a rock trench with a concrete embedment placed by the tremie method. Throughout this length, except at vertical curves, the joints are caulked from the inside. From the rock trench, the pipe for a distance of 550 ft. emerges onto an ocean bed of sand at 75-ft. depth. In the transition from rock to sand, 12-ft. lengths, equipped with fully flexible ball and socket joints, are employed.

The remaining 2450 ft. consists of 18-ft. sections, inside caulked joints alternating with fully flexible ball-and-socket joints; thus the line is in rigid sections of 36 ft. between fully flexible joints. To provide against leakage in event of movement or settlement due to scour, 80 per cent of the joints are caulked from the inside, access being provided by cast iron manholes at 300-ft. intervals along the line, the covers of which are clamped and wedged in place.

• • •

Where millions are at stake, concrete pipe is the answer to a wide range of problems in sewerage and water supply. It is strong, permanent and moderate in cost—the ideal pipe for every job whether 12 inches or 12 feet in diameter. Send for pipe bulletin "*Subaqueous Concrete Pipe Sewers.*"

PORTLAND CEMENT ASSOCIATION

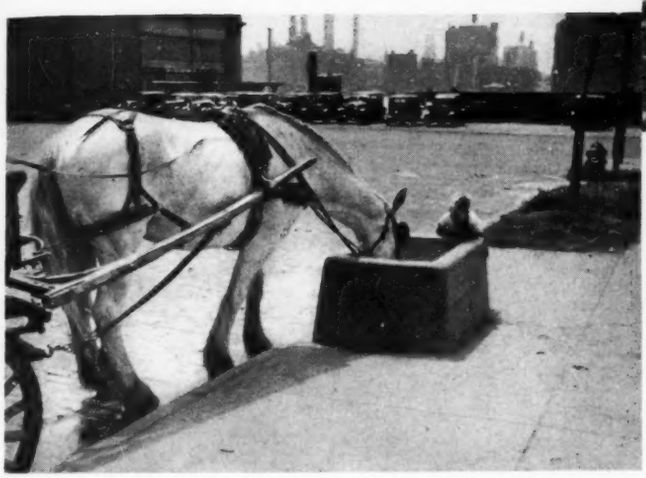
Dept. 3-29, 33 W. Grand Ave., Chicago, Ill.

The best investment on any sewer project is the services of a competent sanitary engineer for design and construction supervision.

PALATABLE DRINKING WATER

. . . IN CITY

IN COUNTRY . . .



. . . IN TROUGH

The DEMAND *is for the* BEST

- HISTORY TELLS US that in 1453 the Turks conquered Constantinople which ended the trading between Europe and the East. It thus became difficult to secure the spices which were so necessary to disguise or mask the objectionable flavors then present in foods.

  Endeavoring to still obtain these desirable spices efforts were made to reach the East by other routes, which officially resulted in the voyages of Columbus who died believing that he had discovered a new way to the East.

  Thus man's craving for desirable flavors was a most important influence in the discovery of AMERICA.

- The elevation of living standards so pronounced during the present century has brought about a corresponding elevation of quality standards in products destined for human consumption.

  Today ACTIVATED CARBON plays a very important part in the removal of objectionable colors, odors, and flavors from many of the food products entering our homes.

  It is no wonder then that the public today demands that the water entering into the home should be as palatable as the foods, etc. Here, too, activated carbon has played an important role these past seven years in helping the Operators of Filtration Plants to furnish a water from which objectionable tastes and odors have been removed. However, many Plants have used activated carbon only when severe tastes and odors are present.

  A recent survey indicated the annual per capita cost of furnishing palatable drinking water through the use of AQUA NUCHAR was less than 3c. May we suggest, therefore, your consideration to applying a small dose every day in the year in order that your Plant will be properly seeded and through this means furnish a palatable drinking water that will enhance the relationship between the water department and the consuming public.

"Make your plans now to attend the 57th Annual Convention of the American Water Works Association, to be held June 7-11, 1937, at the Hotel Statler, Buffalo, New York."

INDUSTRIAL CHEMICAL SALES
DIVISION WEST VIRGINIA PULP & PAPER CO.
230 PARK AVE., NEW YORK
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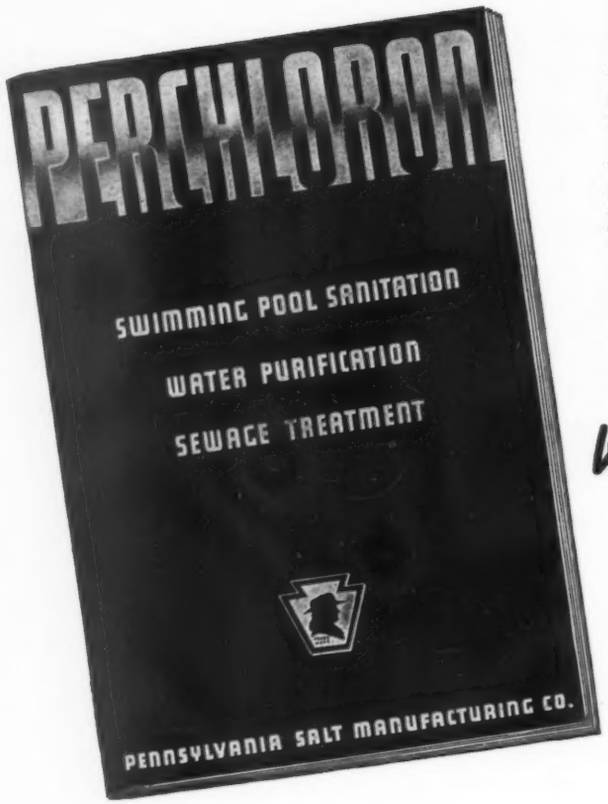
Perchloron

for routine and standby service

...Swimming pool sanitation
...Water purification
...Sewage treatment

EVEN the most rugged and flexible liquid chlorine installations cannot resist floods, fires and other destructive occurrences. In such emergencies, uninterrupted chlorination is assured with an auxiliary hypochlorite installation.

Such protection is always instantly available when you have a supply of Perchloron on hand. With an available chlorine content of more than 70%, Perchloron is both stable and concentrated. It dissolves immediately in water and is perfectly uniform, simplifying technical supervision. Packed 12 handy-sized cans to the case—no return containers to bother with.



Write for this free booklet

A new, 36-page booklet has been prepared, covering the use of Perchloron for Swimming Pool Sanitation, Water Purification, and Sewage Treatment. Preparing Perchloron solutions, emergency feeding, determination of residual chlorine, and the many specific uses of Perchloron are treated in interesting detail. You will find this a highly valuable booklet for general reference. Send for it now.

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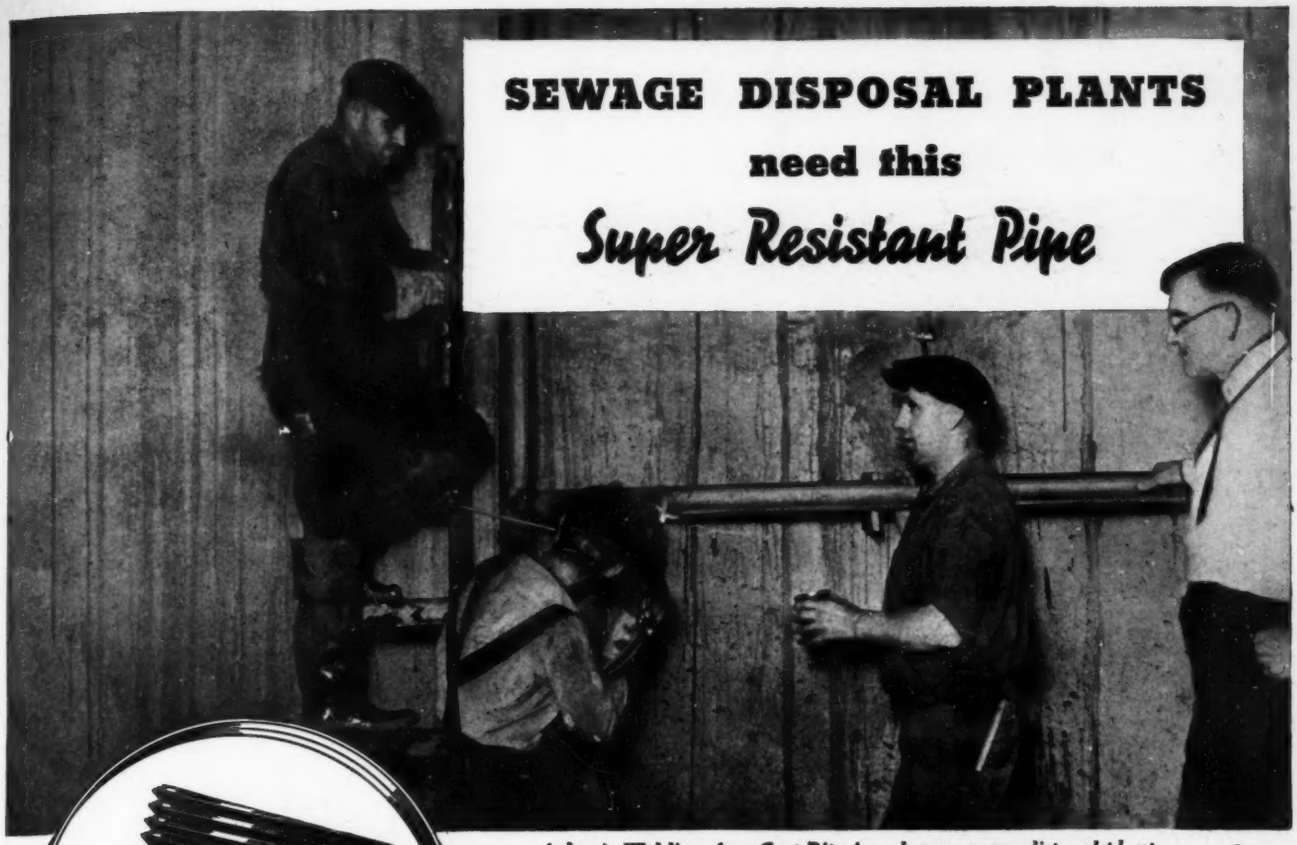
SEWAGE DISPOSAL PLANTS need this *Super Resistant Pipe*



(above) Welding Arco Cast Pipe in a large sewage disposal plant.

No "ethe clean, sharp threads made on the job with standard tools.

EASY TO INSTALL

...it cuts, threads and welds CLEAN with standard tools

Strike at corrosion when you install piping in sewage disposal plants. Use super-resistant Arco Cast Iron Pipe for heating coils in sludge digestion tanks, water lines in activated tanks, and air lines and gas lines to gas collectors.

Wherever corrosion is a factor, Arco Cast Pipe has a successful record. Many industrial plants piping such destructive liquids as hydrocyanic acid, ammonia, bichloride of mercury, and caustic soda have found Arco Cast Pipe thoroughly satisfactory.

Arco Cast Pipe is easy to install — right on the job. It cuts and threads with standard tools — welds smoothly. Because every step of its manufacture is carefully supervised this pipe is free from common defects. It is furnished in sizes 1½" to 12". Sizes up to 6" run 6', 12', and 18' lengths. Other lengths may be obtained on special order. Either or both ends may be plain, threaded one end or both ends, tapped bell, grooved for special couplings, or beveled for welding smoothly on the job.

Remember Arco Cast Pipe for your next sewage disposal job. Make it your standard specification for long-life efficiency.

ARCO PIPE & FITTINGS DIVISION
AMERICAN RADIATOR COMPANY
DIVISION OF AMERICAN RADIATOR & STANDARD SANITARY CORPORATION
40 West 40th Street, New York, N. Y.

Mail this coupon today for the Arco Cast Iron Pipe Manual.

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I am interested in Cast Iron Pipe. Send me your Arco Cast Iron Pipe Manual.

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Firm Name _____

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ARCO CAST IRON PIPE

COLUMBIA

The Columbia River a few miles below Bonneville Dam.

PEACE....

Nature has made the mighty Columbia River wild and turbulent in places, but in others she has graced it with a smoothness of rare beauty inviting peace of mind. ● Manufacturers and other users of the products of THE COLUMBIA ALKALI CORPORATION also find an enviable peace of mind in the quality, uniformity and service that is a part of COLUMBIA.

Send for new folder on COLUMBIA Liquid Chlorine.

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(In Single and Multiple Unit Tank Cars, 100 and 150 lb. Cylinders.)

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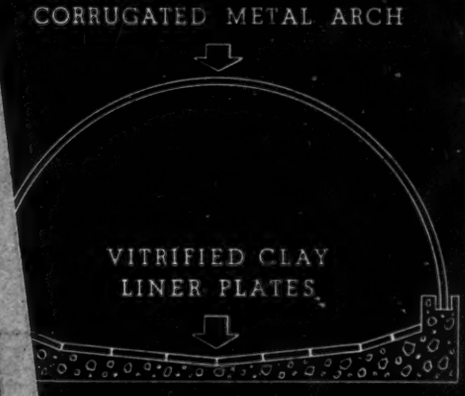
HERE IS A SAFE, ECONOMICAL DESIGN

FOR LARGE SEWERS



• *One of six* Multi Plate arch type sewers being installed in a large midwestern city. The span here is 17 feet and the total length including bends, is 1800 feet. This arch is erected on a concrete base, protected against scouring action by vitrified clay liner plates.

MODERN TYPE OF CONSTRUCTION DEVELOPED BY ARMCO SAVES TIME, TROUBLE AND MONEY

• Designing with Armco Multi Plate, you can build large diameter sewers in less time at less cost than with any other type of material. (Several cities report savings as high as 33⅓ per cent). Even more important, this modern type of construction definitely eliminates the hazard of structural failure.

Multi Plate is amazingly strong and flexible because it consists of heavy corrugated iron plates, ranging in thickness up to 9/32-inch. These heavy plates are assembled in the field by means of special galvanized bolts 11/16 inches in diameter. In various tests, loads up to 350 tons have been sustained by a 20-foot span Multi Plate arch 10 feet long.

Besides these superior structural qualities, Multi Plate also assures a high degree of material permanence. Many Armco Ingot Iron sewers, made of 14 and 16 gage galvanized metal, are sound and strong today after *30 years of service.* This same metal in Multi Plate is *3 to 4 times as thick* and the galvanized coating is much heavier. For more specific data bearing on your problems, address the coupon to: Armco Culvert Mfrs. Association, Middletown, Ohio.

ARMCO

MULTI PLATE

MULTI ARMCO PLATE

☐ Tell me more about the use of Armco Multi Plate for large sewers.

Name_____

Title_____

Address_____

(WWS-3-37)

HOW TO HANDLE IT IF IT IS SCREENINGS

The Rex Triturator brings new advantages to shredding sewage screenings . . . .

● The Rex Triturator* now provides the ideal means of disposal for sewage screenings. Installed either as shown above for hand feeding or automatic control, it provides all the advantages of complete screenings disposal within the system. Its clean-cut shearing action of 350,000 blade cuts per minute completely disintegrates rags, papers and all forms of organic solids. The residue is returned to the sewage flow and becomes additional primary sludge.

The work is done with very low water and very low power consumption.

The Rex Triturator is a substantially built unit. It consists essentially of a toothed rotor revolving at high speed between two grates with the cutting teeth intermeshing the grate bars. Pivoting of the grates under heavy spring pressure provides for yielding of the grates under excessive loading, allowing the passage of tramp material without severe damage to the machine.

The Rex Triturator is new in design, appearance, operating principle and performance. Its capacity is large, operation simple, and power and maintenance cost low.

**Webster's Dictionary: Triturate — to comminute thoroughly.*

A new bulletin on this new addition to Rex Sanitation Equipment is now ready. Send today for your copy of The Rex Triturator Catalog.

CHAIN BELT COMPANY
1610 W. Bruce St., Milwaukee, Wis.

REX

CHAIN BELT COMPANY
of MILWAUKEE

Sanitation Equipment

NON-SHRINK EMBECO

ELIMINATES Shrinkage in Concrete

FOR the successful repair or restoration of filter tanks, settling basins or any other concrete structure, Non-Shrink Embeco provides the ONE sure method of making such repairs *permanent.* Non-Shrink Embeco is a specially prepared metallic aggregate which entirely eliminates shrinkage in concrete, thus creating a perfect bond with the old concrete and building into repairs a tremendous strength and resistance to attack by corrosion or weathering. Non-Shrink Embeco is quick-setting, attains high early and great ultimate strength—and it's SHRINKPROOF!

● *Thousands of successful jobs! List on request. Above: Cleveland sewage disposal plant, restored with Embeco.*

● *Actual unretouched photograph of the perfect bond Non-Shrink Embeco makes when used for repairs. The dark area is shrinkproof concrete made with Non-Shrink Embeco; the lighter area the old concrete.*

● *Send for the pictorial specifications shown below.*

THE MASTER BUILDERS CO.

CLEVELAND, OHIO — TORONTO, ONTARIO

Dangerous Waters!

WHEN floods bring the threat of polluted water supplies and of water-borne disease, HTH proves itself an invaluable ally to water works and health officials. With HTH, emergency hypochlorination can be applied quickly, on the spot, wherever pollution is found. A highly concentrated chlorine carrier, containing 70% of available chlorine, quickly soluble in water, HTH can be transported to the job and put to work before a dangerous situation has time to develop.

Then there is the aftermath of flood conditions, as receding waters leave a seemingly hopeless task of cleaning up and disinfecting flooded areas and buildings of every kind. Here again health authorities find HTH of invaluable assistance in restoring sanitary conditions in scores of places where a less concentrated, less mobile or less soluble source of chlorine cannot serve as effectively.

Fortunately, floods do not strike frequently at the average community nor do they strike so quickly as to find local officials wholly unprepared. But there are day-to-day emergencies, too, which require prompt and effective chlorination—broken water mains, an abnormal water load due to a serious fire, polluted wells, failure of a chlorinator, an interruption in the power supply—just the sort of jobs for which HTH is made to order.

No wonder that so many experienced water works men keep an ample supply of HTH always on hand, not only as an important measure of preparedness for every sort of emergency, but also because they find it so useful in scores of every-day sanitation jobs! Write or wire us for full information and nearest available stock.

The MATHIESON ALKALI WORKS (Inc.) 60 East 42nd St., New York, N. Y.

Liquid Chlorine . . . HTH and HTH-15 . . . Soda Ash . . . Caustic Soda . . . Bleaching Powder . . . Bicarbonate of Soda
Ammonia, Anhydrous and Aqua . . PH-Plus (Fused Alkali) . . . Solid Carbon Dioxide

BE PREPARED WITH HTH FOR ANY EMERGENCY!

ALOXITE

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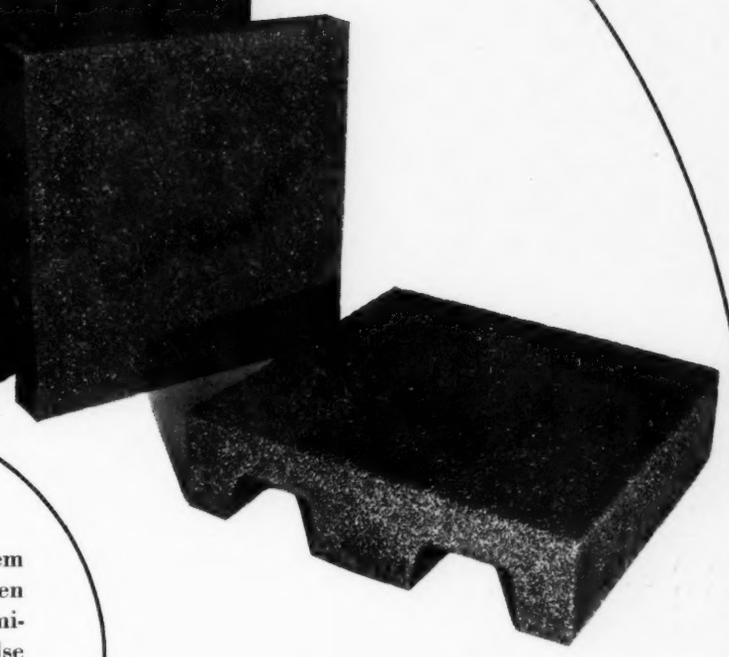
BRAND POROUS MEDIUMS

in the water treatment field!

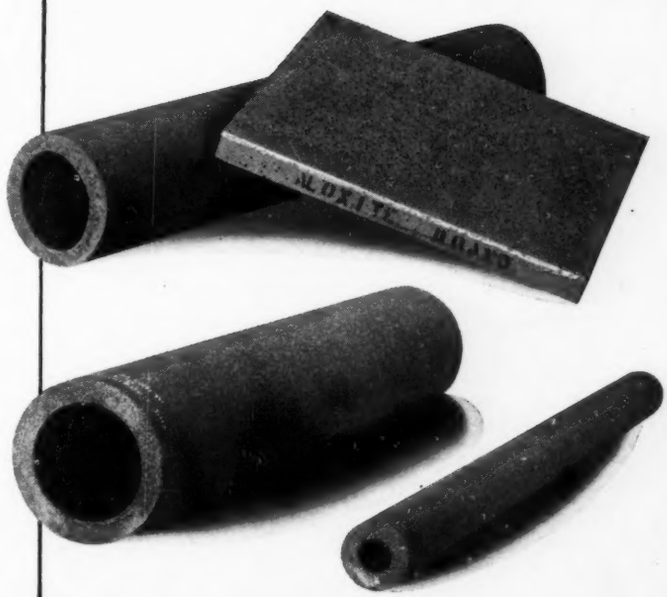


1 *The new RSF Porous Plate Underdrain* system with channels for rapid sand filters. Then there are plain porous underdrain plates of similar special coarse structure for use as a false bottom in filters of either pressure or gravity type.

2 *Diffuser Plates and Tubes* for aeration of water and mixing of chemicals. Proved by experience in many cities as an economical and effective method of accomplishing such objectives.

3 *Diffuser Tubes* for recarbonation chambers. The most efficient way to introduce clean CO_2 into water. Practiced successfully at Beverly Hills, California and elsewhere.

4 *Filter Tubes* for direct filtration of industrial water supply.



Write for technical literature and submit your water treatment problem to our Sanitary and Filtration Department.

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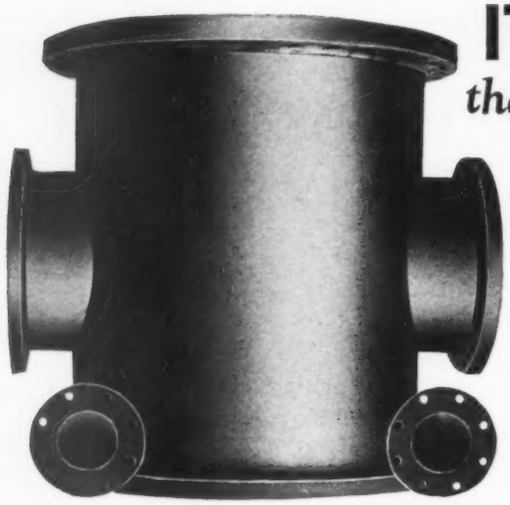

IT IS THE UNUSUAL—
that brings out Foundry Technique

"LYNCHBURG" has built its enviable reputation on its ability to produce difficult "SPECIAL" fittings and big cast iron pipe of the finest quality—work that demands the best Foundry Technique . . . Special equipment, and an organization trained to the job enable us to boast that a job does not come too large or difficult for us to handle with dispatch . . . Write, Wire or Phone "Lynchburg" for quick estimates.

Bell and Spigot Pipe and Fittings. From 4" to 54".
Cast Iron Flanged Pipe. From 3" to 84".
Cast Iron Flanged Fittings and Flanges. From 1" to 84".
Super-de Lavaud Centrifugal Cast Iron Pipe.

Special Iron Castings for the Chemical Industry

Make your plans NOW to attend the 57th annual convention of the American Water Works Association to be held June 7-11, 1937, at the Hotel Statler, Buffalo, N. Y.

LYNCHBURG FOUNDRY COMPANY

Peoples Gas Building
Chicago, Ill.

GENERAL OFFICE - LYNCHBURG, VIRGINIA

50 Broad St.
New York, N. Y.

IDEAL GAS BOILERS
for Modern Sewage Disposal Plants

A *partial* list of
AGP INSTALLATIONS
in Sewage Disposal Plants
throughout the country. Models from 31,500 to 3,840,000 btu per hour capacities meet every requirement.

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Britt, Iowa
Boulder, Colo.
Bowling Green, Ohio
Carrington, N. D.
Clear Lake, Iowa
Cleveland, Ohio (East)
Cleveland, Ohio (West)
Colton City, Calif.
Columbus Grove, Ohio
Coney Island, N. Y.
Cotton City, Calif.
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Park Rapids, Minn.
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Poughkeepsie Hosp., N. Y.
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Walden, N. Y.
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Willmar, Minn.
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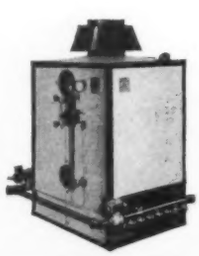
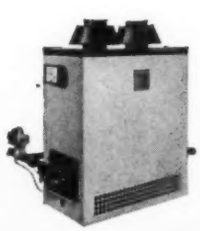


Model 1-G
Four to eleven sections.

AGP

Model 4-GA
Eight to thirteen sections.



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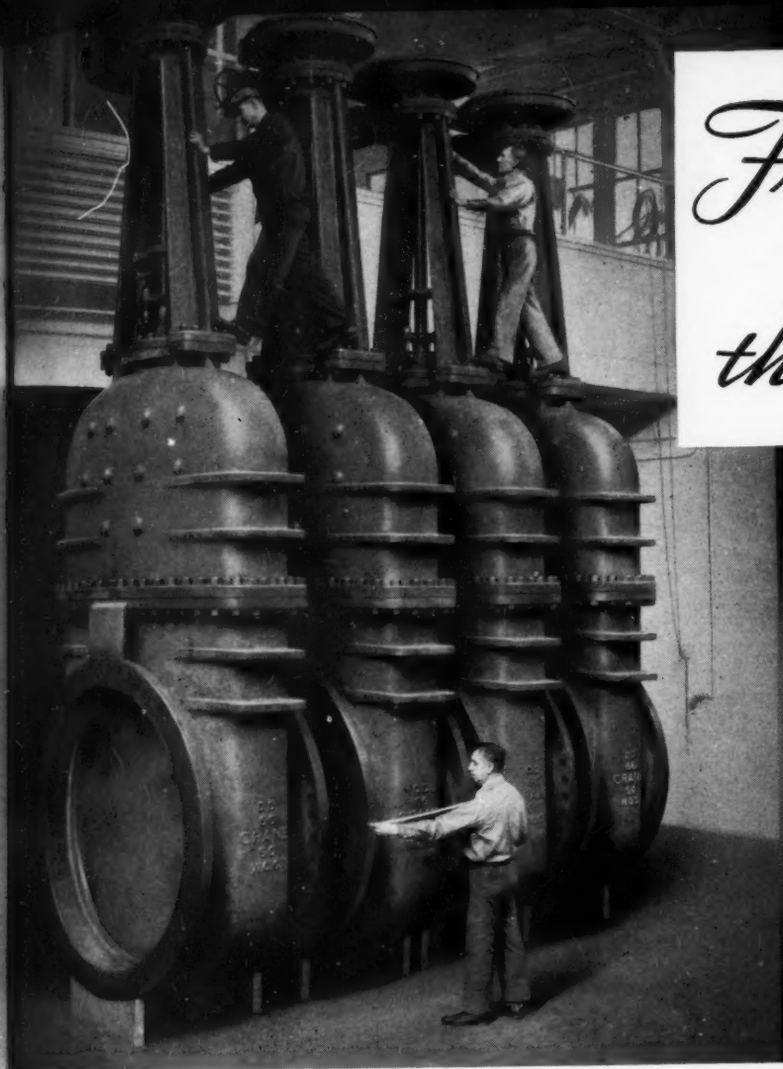

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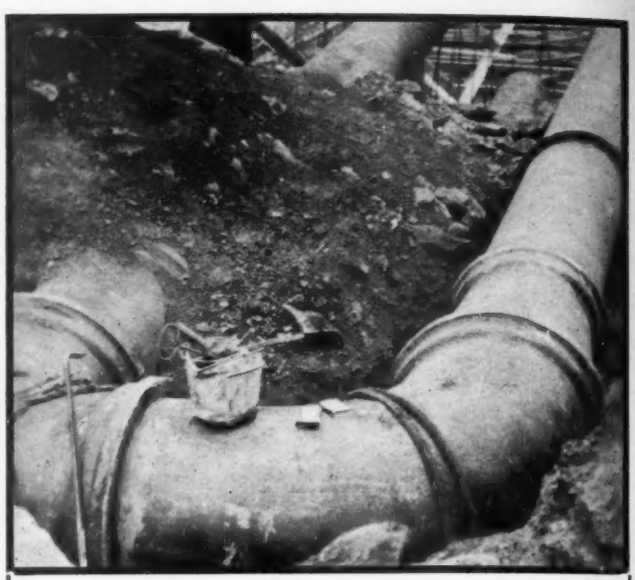

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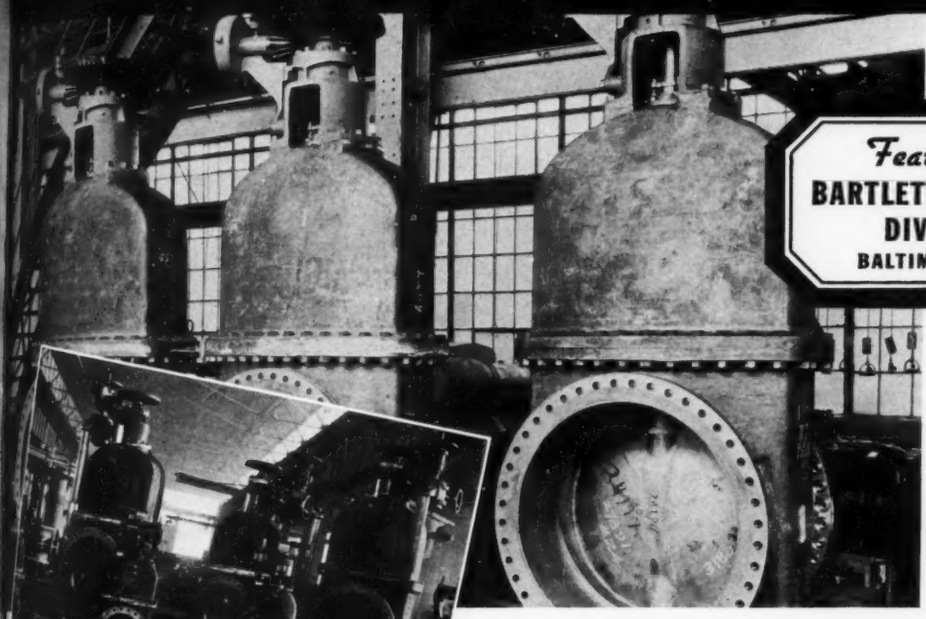
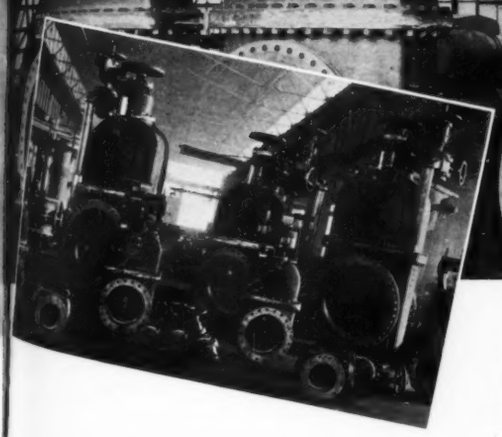
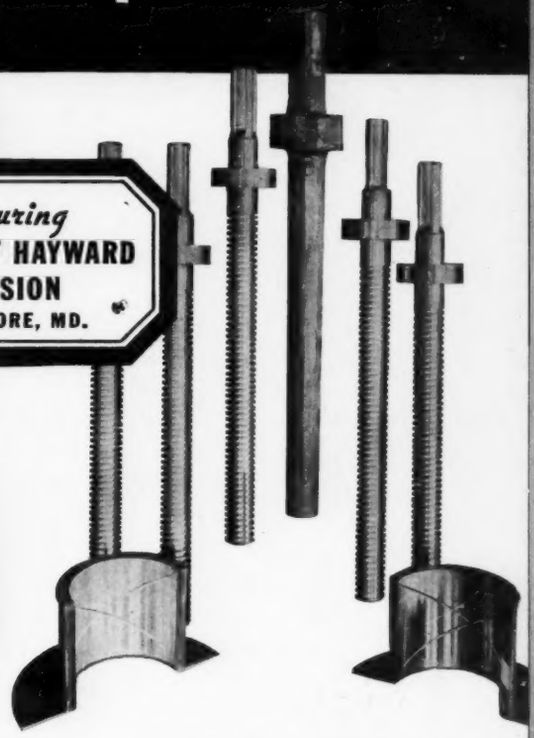




KOPPERS BARTLETT HAYWARD DIVISION FURNISHED 43 OF THESE BRONZE VALVES FOR CITY WATER TUNNEL NO. 2, NEW YORK BOARD OF WATER SUPPLY—These 48-inch manganese bronze valves were installed in 15 chambers in the tunnel running from Hill View Reservoir, Yonkers, N. Y. to Hamilton Avenue, Brooklyn, N. Y.



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This photograph shows a typical forging of D-H-S Gra No. 2 Bronze, and a number of finished valve stems machin from these forgings. These forgings were part of a contract f eight 18-inch bronze by-pass valves at the Fort Peck Dam. total of 350,000 lbs. of D-H-S Bronze and 1,200,000 lbs. Bartlett Hayward manganese bronze are being used in the F Peck Dam. The use of bronze in the Fort Peck Dam is the fi known use of bronze in tunnel linings.

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Ultimate Tensile Strength, Lbs. Sq. In.	100,000	121,000
Yield Point, Lbs. Sq. In.	65,000	99,500
Elastic Limit	50,000	66,200
Elongation Per Cent in 2"	10	12.
Red. of Area	10	12.
Brinell Hardness No.	228	241

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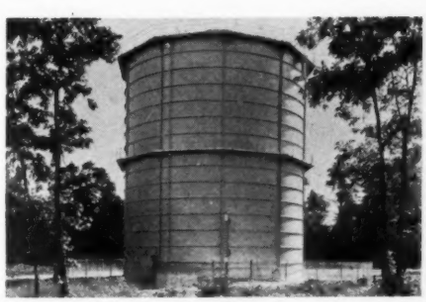

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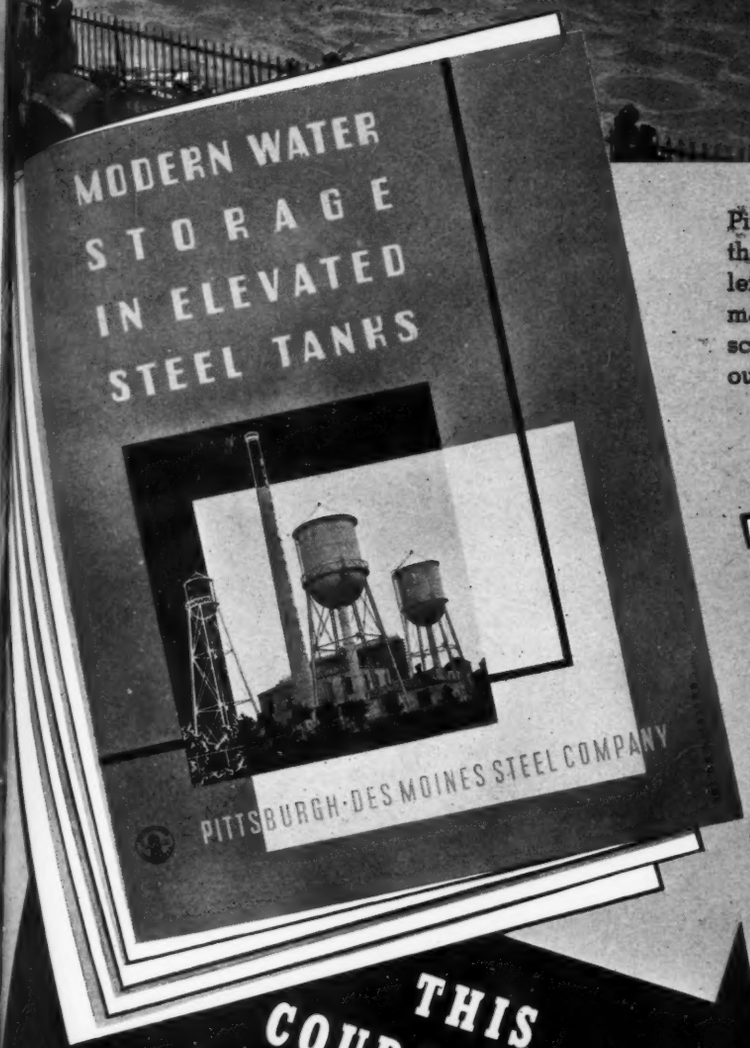

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WATER WORKS & SEWERAGE

E. S. GILLETTE, Publisher

L. H. ENSLOW, Editor

ARTICLES AND AUTHORS Scheduled for Future Issues

Pipe Line Corrosion Control by Deaeration" relates experiences with, and results from, a mechanical cold-water deaerator installed on a long steel main for the purpose of reducing the oxygen content of the water. The end sought was that of remedying corrosion and tuberculation troubles, experienced in the past, without the necessity of increasing hardness of the supply by adapting the popular, but somewhat questionable, municipal practice of liming the water. The authors are Sheppard T. Powell and H. E. Bacon, Jr., Consulting Chemical Engineers of Baltimore, Md.—the senior author being too well known, as the result of his contributions to water supply and treatment practices, to require introduction. This paper, delayed for longer records of accomplishments with the process, has been announced several times. Its importance justifies the repeat announcement of this paper which is assured for the April issue.

"Some Consideration in the Design of Small Sewage Works" is to be presented by W. B. Walraven, America's "Ace" in sludge-gas power-engineering, of Springfield, Ill. He contends that, this is a story often told; but agrees that it needs re-telling. In the present day of development and change in sewerage practice and sewage treatment, Mr. Walraven's article based on practical operating experience and design, and the observations of a student, all go to the making of his article one well worth the "re-telling"—and, re-reading. If every designing engineer had to pass through an operating apprenticeship, their drafting boards would the better plants produce. To read Mr. Walraven's article is to take a post graduate course in sewage works design.

"Water Loss and Leakage Control" is a contribution from Johannesburg, South Africa. Mr. M. Udwin, Rand Water Board's Chief Engineer, relates their experiences with leakage control and tells how it has been possible to reduce unaccounted for water (water loss) to the extraordinary low figure of 1.34 per cent. More remarkable, is the fact, that this becomes a sustained efficiency in the operation of Mr. Udwin's distribution system. It would appear that America his something to learn from the Transvaal.

"Impressions of an English Sewerage Works Meeting" contributed by Dr. W. Rudolfs, at the request of WATER WORKS AND SEWERAGE, will interest many sewage workers and sanitarians in America. Dr. Rudolfs sets forth the processes of and proceedings transpiring during typical meetings of the British Institute of Sewage Purification, which is composed of works-managers, engineers and drainage-basin (rivers) authorities. As a keen observer, Dr. Rudolfs' impressions are enlightening, and may well prove suggestive to officials of American associations.

"Marking Fire Hydrants" is a "Kink" to be revealed by W. M. Rapp, Superintendent of Distribution and Construction of Atlanta's Water Department—recently honored by A.W.W.A. in being named for Honorary Membership in this Association, a recognition justly deserved.

Vol. 84, No. 3

CONTENTS for MARCH, 1937

Sewerage and Sewage Treatment in Review 71
By CHARLES GILMAN HYDE
Professor of Sanitary Engineering, University of California, Berkeley, Calif.

Experiences With Ferric Chloride at Emporia, Kan. 81
By S. F. KUNZ
Chemist, Water Department, Emporia, Kan.

Experience With Porous Plates for Filter Underdrain at Denver, Colo. 84
By O. J. RIPPLE
Supt. of Filtration, Denver, Colo.

A Few "Kinks and Gadgets" in the Operation of a Water System .. 86
By CARL A. HECHMER
Dept. Engr., Washington Suburban Sanitary District, Hyattsville, Md.

The Newer Methods of Sewage Works Financing 88
By C. W. KLASSEN and W. H. WISELY
Illinois Department of Public Health, Springfield, Ill.

Experiences in Well Construction 94
By J. A. CARR
Superintendent Water Department, Ridgewood, N. J.

Some Laboratory Kinks and Time Savers 96
By C. AUSTIN HABERMEHL
Senior Sanitary Chemist, Bureau of Sewers, Detroit, Mich.

Some Comments on Corrosion in Water Works Practice 99
By CARL N. ALEXANDER
Supt of Filtration, Tubize Chatillon Co., Rome, Ga.

N.E.W.W.A. Features Chlorination Topics 102
By HARRY A. FABER
Associate Editor

Practical Hydraulics: Measurement of a Head on a Weir 105
By P. S. WILSON
Assistant to the Secretary of the American Water Works Association

Flow Study on "Separate" Sanitary Sewer System 107
By V. W. WILLITS
Consulting Engineer, Los Angeles, Calif.

Editorial 108

Equipment News 62

Catalogs and Literature Received 66

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WATER WORKS AND SEWERAGE
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VOL. 84 MARCH, 1937 No. 3

SEWERAGE AND SEWAGE TREATMENT IN REVIEW

Part 2—Some Comments on Sewage Treatment

By CHARLES GILMAN HYDE, C.E.
Professor of Sanitary Engineering,
University of California, Berkeley

The first installment of Professor Hyde's able and pains-taking review, with here and there his interesting and timely comments on developments and trends in the ever growing field of sewerage and sewage treatment, is to be found in our February issue.

Too voluminous for printing in a single issue, and too excellent and readable to cut, we decided to devote to it the required space divided between two consecutive issues.

As to the reader, we hope that from Professor Hyde's contribution he may get as much pleasure in the reading as did we. And, as much of value in the way of a quick insight into the new developments in this rapidly moving field of sewage disposal.—Editor.

Screenings Disposal

JUST four years ago the Sanitary District of Chicago began a series of experiments at its North Side Plant to determine the feasibility of grinding the screenings taken from a bar rack and of returning the ground material to the sewage flow with the aim to reduce the volume of screenings to be removed by converting the solids to settleable material. The idea has taken hold and has been adopted, with the aid of some of the equipment recently developed for the purpose, in scores of places in this country. Garner has recently stated that also in England, the disposal of screenings in this manner is extending.

Already several machines have been placed upon the American market to accomplish this end. One of the pioneer solids comminutors performs the work in the sewage stream without removing the screenings therefrom. Others are primarly adapted to operate in conjunction with hand and mechanically cleaned bar racks. To macerate, cut, or shred the solids removed by the screens and return the material to the sewage. The determination of the proper type to employ rests upon local conditions and of course upon relative installed and operating costs.

In England pumps whose impellers are studded with knives have been employed to comminute the coarser sewage solids. There is some evidence that the grinding of screenings as preparatory to digestion is valuable. In the words of Fair, the parameters of digestions are increased by comminution.

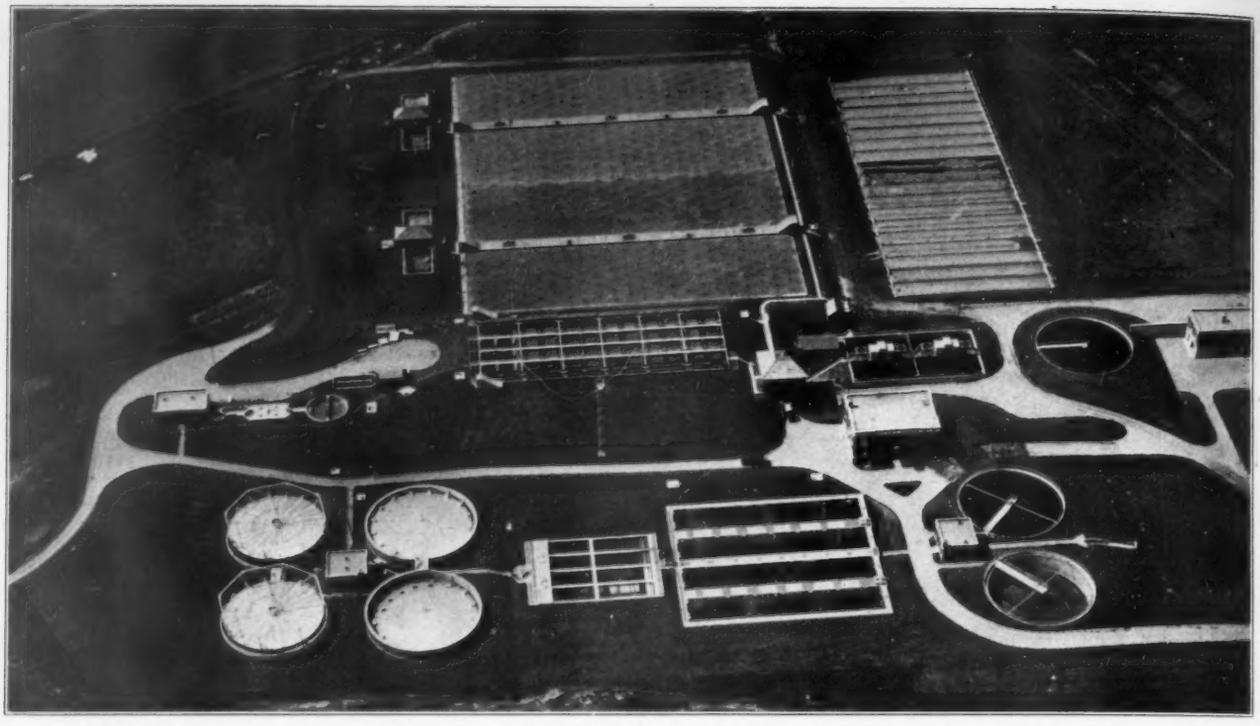
Grease Removal and Clarification

The conditioning of sewage to effect the highest possible degree of clarification by subsidence is now receiving much deserved attention. The removal of grit, where that is necessary, has of course been practiced for years so that the methods and mechanisms are all too well known to warrant any consideration here. Although at a few places for a long time grease has been partially removed from sewage by some sort of skimming, the procedures for the most part have been crude and ineffectual.

More recently better methods of removal of grease from sewage, as preparatory to clarification have come into use, particularly those based upon Imhoff's ideas as first put into practical effect at Essen-Rellinghausen. At a number of the newer plants, notably the Easterly Works at Cleveland, aeration is thus being utilized to bring grease, oil, and scum to the surface.

At Woonsocket, R. I., through studies initiated by the Chlorine Institute, it was learned that a minor amount of chlorine admitted to the pipe carrying air to the diffusers has remarkable effects in enhancing grease separation in the pre-aeration process (Imhoff) of grease removal.

During the past year the city of San Francisco erected an experimental plant of about 150,000 gallons per day capacity to ascertain the feasibility of removing both grease and grit from sewage in a single tank. The scheme proved to have sufficient merit to warrant its inclusion in the 15 m.g.d. plant, now under design. The removal of grease will be accomplished by a modified Imhoff method employing pre-aeration which in most previous installations have been of too brief duration. In the San Francisco design the nominal retention period, at design capacity, will be fifteen minutes. Each of the four tanks will be provided with three transverse baffles, spaced 11 ft.-7 in. apart on centers, to reduce short circuiting to a minimum. The experiments indi-



Competition! The Most Recent Addition to the Madison (Wis.) Treatment Works Is the Activated Sludge Plant in the Foreground. The Flow Is to Be Divided Between the Older Trickling Filter Plant and the New Plant. What Is the Answer to Be?

cated 0.05 cubic foot of air per gallon of sewage to be ample with the 15 minute period. The grit, made reasonably free from organic matter by aeration-scour, will be removed from the tanks by bottom scrapers, pumped to an elevated sand washer and thence to a bin, whence it can be removed by truck and disposed of as fill. The grease will be pumped to a sludge concentration tank, which will also receive the macerated screenings from mechanically cleaned bar racks. The mixture will be pumped to two-stage heated digestion tanks.

In July, 1933, Benas of San Francisco conducted a series of experiments to determine what degree of improvement, if any, in the clarification of sewage by subsidence could be effected by simple rotation of the sort employed for flocculation in connection with water and sewage coagulation. He surmised that typical sewage contained fibrous and other material capable of purely mechanical agglomeration in that manner. Various paddle speeds and periods of stirring were tested. The results were unexpectedly favorable and indicated that an improvement, to the extent of 15-30 per cent greater oxygen demand reduction, could be anticipated as compared with the unstirred sewage. During the summer of 1936 a more comprehensive series of tests were conducted with similar results. The proposed Richmond-Sunset plant for San Francisco is accordingly being designed for a nominal average period of 30 minutes of "self-flocculation" without chemicals. Each of the four sedimentation basins will be provided with its own flocculation tank. Each of these tanks will have four equal compartments with series spiral flow, patterned after the first or older coagulating tanks at Sacramento, to reduce short circuiting to the lowest possible terms. The paddle speeds will be highest in the first compartment of each series and will be successively reduced thereafter, but not to a velocity where deposits can occur. Several plants have already been constructed in America to utilize the flocculation principle in chemical precipitation and the results are reported to be quite satisfactory. San Francisco is the first to develop and employ "self-flocculation," subject to chemical aid if and when justified.

Several extremely valuable technical papers discussing the basic theory of sedimentation, and reciting the conclusions determined from a certain amount of experimentation with models, have been recently published. Among such should be mentioned those by Morrill, Schroepfer, Slade and Camp, which are distinctly helpful in elucidating the problems involved and in suggesting better methods of attack by designing engineers.

Too much stress cannot be placed upon the necessity for the more rational design of clarifier inlet and effluent devices. It is highly important that the energy of the incoming sewage be dissipated at the inlet in such manner that adverse currents are not set up in the basin. The effect of wind is also of greater significance than is commonly realized. The effect of temperature, however, has long been appreciated but as Mark Twain said with respect to the weather "nothing is done about it." Possibly, the best thing that can be done about either wind or temperature is to cover sedimentation basins. This will be done at the Richmond-Sunset plant in San Francisco despite the general equableness of the climate.

Unpublished experiments, conducted on a comprehensive scale in the Middle West, have demonstrated the very great importance of proper location and length of effluent troughs. At the Richmond-Sunset plant in San Francisco the sedimentation basins will be 33 ft. wide and 100 ft. long. Each will contain four longitudinal steel troughs equally spaced across its width. Each trough will be 25 ft. long and the 200 lineal feet of lip in each basin will be provided with rectangular notches 1¼ in. wide and 6 in. deep on 12-in. centers. The San Francisco designs have been made such as to lend themselves to chemical treatment, which may be adopted in addition to planned pre and post chlorination at some future time, as a seasonal treatment. It may be

of interest to note that, based upon practical tests, it is proposed to remove such grease and scum as may collect on the surface of these basins by fine sprays of settled sewage or water. Such sprays will "herd" the floating material into one corner at the inlet end of each basin when it will be removed by specially designed depressible troughs. Similarly the grease, oil and scum from the combined grease and grit removal tanks, previously mentioned, will be removed.

Hubbell at Dearborn has conducted some illuminating experiments with model inlet devices constructed on a one-twenty-seventh scale to discover an improved method of distributing the sewage entering the Imhoff tanks already constructed and in service. Distributors of a design suggested by the tests have been installed and as a consequence the percentage removal of suspended solids by the Imhoff tanks has been raised. Some early observations seemed to show an improvement of 26 per cent, or an increase in the percentage of solids removed from 48 per cent to 74 per cent.

At Columbus, Ohio, Alton has employed a novel surface take-off trough arrangement in the final settlers. These troughs extend forward approximately three-fourths of the length of the rectangular tanks, being fed, also, by cross-troughs. (See picture.)

Recent clarification plant experiments indicate that sedimentation through two tanks operated in series, with the same total nominal retention period, gives better results due to improved distribution and displacement than does parallel flow, wherein short circuiting is a greater potentiality.

Chemical Treatment

The history of chemical treatment as applied to sewage, the reasons for its recent recrudescence, its probable field of usefulness—all have been discussed by many competent writers in numerous technical papers.

A year ago the available data indicated that some 36 chemical treatment plants were then in operation in 35 places in the United States, that 9 plants were under construction and that 18 others were projected. The figures for the present moment are not at hand. Several chemical treatment plants are still in operation in Great Britain as relics of an earlier period. But it does not appear that the process, utilizing the newer knowledge and equipment, has been adopted in Great Britain. Here chemical treatment has been adopted largely for seasonal use to reinforce plain subsidence at low receiving stream stages or to serve as an assisting treatment to biological processes.

It is now generally recognized that chemical treatment, as the term is here used, has a rather definite field of service as an intermediate process yielding generally better effluents than can be obtained with subsidence alone and generally poorer effluents than are obtainable with efficiently functioning biological processes. Coupled with subsequent filtration through magnetite, sand or anthracite filters, chemically treated effluents can be materially improved both as related to suspended solids and B.O.D. In several recent instances such filters, productive of improved effluents and chemical savings—especially magnetite filters—have been installed as an adjunct of chemical treatment.

Plants now employing chemical treatment under actual practical conditions are beginning to furnish data which define the efficiency, the limitations and the cost of the process utilizing present-day methods and equipment.

All sewages are not amenable to effective treatment with reasonable chemical dosages. But if the cost of chemicals can be sufficiently reduced because of increased demand or manufacture as by-products, the extent to which chemical treatment can be utilized economically in comparison with the biological processes will to that degree be broadened.

Beyer states that the experience gained at the twelve or more plants using the Scott-Darcy Process in Arkansas, Kansas and Oklahoma indicates that the general use of chemicals per million gallons may be taken as follows:

Chlorine for ferrous or ferric chloride production.	30 to 50 lbs.
Lime for supplementary treatment.....	300 to 400 lbs.
Lime, additional, for vacuum filtration of fresh sludge	300 lbs.
Chlorine for disinfection (following effective sedimentation with ferric chloride).....	25 lbs.

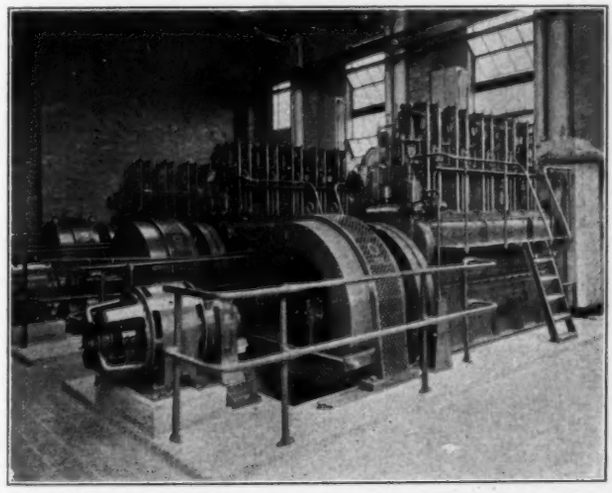
Jung is of the opinion that the high iron content ot sewage sludges resulting from the use of ferric coagulants is not prejudicial to digestion. To the contrary his experience indicates that 25 per cent more gas was developed than when the iron salts were absent. Others have observed similar effects.

Investigations recently made by Rudolfs and Gehm indicated that over the entire pH range studied (pH 2.0-11.0) there was a definite relationship between the suspended solids and the turbidity of chemically treated sewage. They therefore have concluded that, in conjunction with the determination of the pH of sewage and effluent, the turbidity measurement is a simple and easy means of controlling the chemical treatment process, including the regulation of the dosage.

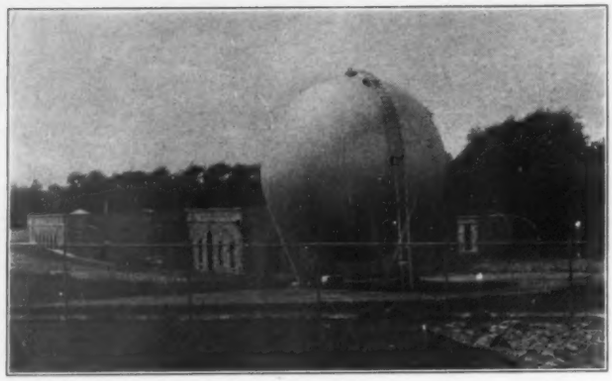
It is recognized both in America and abroad that chemical pre-treatment applied to certain types of industrial wastes is valuable. In America it has been found that the mere addition of iron salts in amounts less than are requisite for precipitation raises the efficiency of trickling filters markedly. On such findings the Plainfield, N. J., plant continues to operate and new plants for Atlanta, Ga., have been designed to recognize the experimental findings there.

Chlorine as an Adjunct

Chlorine continues to be the most widely employed and the most useful chemical servant of sewage treatment. Its utilization for disinfection, for odor control, for the oxidation of organic matter and for other purposes connected with the treatment of sewage and trade



America's Largest Power Development with Sewage Gas, Yet in Operation. At New York City's Coney Island Plant—3 Gas Engines of 300 H.P. Each Grind Out All Power Needed from Sludge Gas.



Even the Smaller Plants Are Being Equipped for Gas Utilization. Beaver Dam's (Wis.) Spherical High Pressure Holder Adds Interest.

wastes has been effectively told and retold. There is little therefore which need be said here in addition.

Rudolfs and his colleagues have found that chlorine dosages only partially satisfying the demand, if given thorough mixing and adequate time, have rather surprising powers of bacterial destruction. For instance, it was discovered that a dosage representing only 50 per cent of the demand was capable of killing 90 per cent of the B. coli present in the sewage tested after a contact 15 seconds or less, provided the mixing was quick and thorough. As a practical matter, however, not only should the fact of thorough mixing be stressed but a relatively long contact period should be provided, where feasible, to insure the desired results.

The application of chlorine up the sewer, or at as early a stage in the sewage treatment process as the local conditions will permit, may be advocated with some reasonableness. The large Coney Island, N. Y., plant has operated economically and effectively on pre-chlorination solely. Others have had like experience in establishing the economy and practicability of pre-chlorination, notably the Los Angeles County Sanitation District which chlorinates at several remote points on its major sewers.

Ricker at Princeton, N. J., has found that pre-chlorination ahead of the plant in combination with the addition of chlorinated iron, manufactured at the plant (Scott-Darcey method), has a demonstrable value and economy preventing odor nuisance. Incidentally he has discovered that it has improved trickling filter and digester performance.

For some ten years the effect of chlorine dosages upon the B.O.D. of sewage and sewage effluents has been under observation. It seems to be generally conceded that for each part per million of chlorine added (up to the complete satisfaction of chlorine demand of the sewage or waste), a two parts per million reduction in B.O.D. will be had. With ordinary sewages, when chlorinating to the extent of the full demand, one may be expected to reduce the B.O.D. some 25 p.p.m. The stronger sewages and wastes show greater reductions with, also, increased chlorine demands.

Activated Carbon Experiences

Activated carbon is a "new comer" among the chemicals employed in sewage treatment. It is apparently being used both in America and abroad, but as yet to a limited extent.

The use of activated carbon at Newark, N. Y., is reported to have reduced scum formation to the extent of 75 per cent and also odors due to hydrogen sulphide. It is further stated that the methane content of digester gas has been increased, that the volume of gas has been increased 25 per cent, and that the drainability of the digested sludge on sludge drying beds has been improved with resulting freedom from odors. Rudolfs and Trubnick have noted similar effects as related to sludge digestion and to the reduction of scum formation on settling tanks and of odors. They further point out that the B.O.D. of incompletely oxidized effluents and of chemically treated sewage can be further reduced by the use of activated carbon. Garner and Lovett of the West Riding of Yorkshire Rivers Board are authorities for the statement that activated carbon raises the pH value of sewage, reduces the efficiency of chlorine as a disinfecting agent and aids materially in sludge digestion but does not assist the flocculation of suspended solids. From Baltimore, Md., comes a report (results to be published) which show a speeding up of digestion, and the production of gas with greater heat value due to the higher methane content.

[The paper in question by Messrs. Keefer and Kratz has since the preparation of this review appeared in our February issue.—Ed.]

Trickling Filtration

Among the final treatment processes, defined as capable of yielding stable effluents, the trickling filter process continues to hold a large numerical advantage over other biological processes.

Trickling filter plants, serving communities having populations of 2,500 or over, outnumber activated sludge plants about four-and-one-half to one.

The activated sludge process, and more recently chemical treatment, have for some time past held the spot light as far as technical discussions are concerned. This has become true in spite of the important inherent advantages which the trickling filter possesses. Perhaps one reason for this situation lies in the fact that the design, construction and operation of trickling filters are all relatively simple matters, or have been so regarded. It is generally conceded, and increasingly appreciated, that this type of treatment will stand more shock due to overloading, caused by trade wastes, stale sewage and the like, and will produce more uniform effluents with less attention than any of the other complete treatment processes. Its greatest practical handicaps, in comparison with the activated sludge process, have been its liability to odors, its relatively large area requirements, and its usually high construction or investment cost per unit of capacity. It should be added, however, that this applies in so far as such capacity has been rated up to the present time. Nevertheless, even with this low rated capacity the total annual costs of the process have been generally lower than those of the activated sludge process—and, for the smaller plants, materially lower.

An intense new interest has been aroused in the trickling filter through recent investigations which show that with proper care and manipulation this process can handle loadings several times as great as those which were thought to be possible until now. The new evidence suggests that the required area or volume may be but a fraction of accepted design values in the past and, therefore, that the installation cost can be materially reduced. If this be true, trickling filter plants ought to become cheaper to construct and considerably cheaper to operate than any other type of final process. When the loadings are extremely heavy and effluents of high quality are essential, double filtration

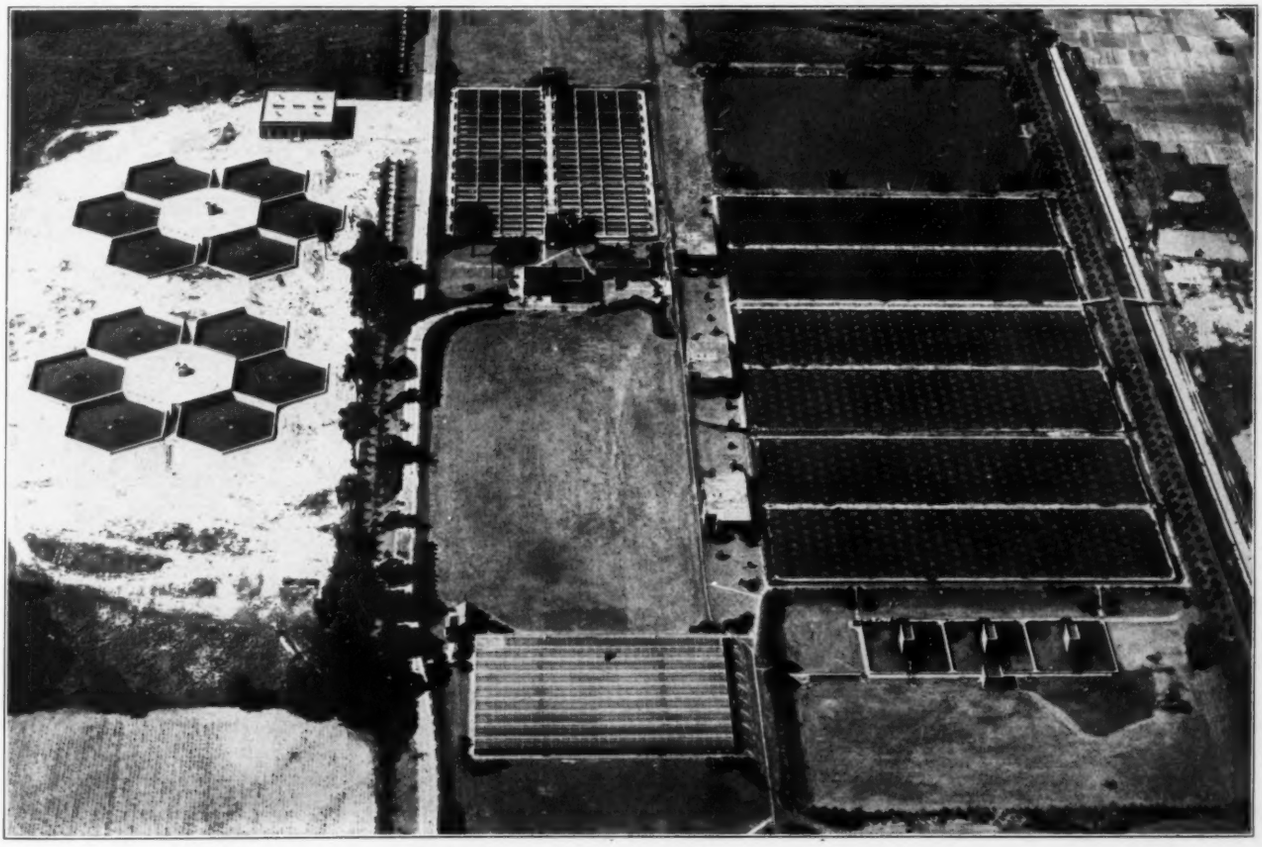
may be necessary. With high filtration rates, which seem to induce colloider action or biological flocculation to a much greater degree than do low rates, secondary settling becomes a materially more important step in the process. Here, too, a straining type filter may be termed to be particularly advantageous.

In October, 1931, the late J. A. Childs and G. J. Schroepfer presented a paper at the St. Paul meeting of the American Society of Civil Engineers in which the available data from 15 trickling filter plants in 7 states were critically reviewed. While these data were somewhat ragged, the results were sufficiently consistent to be fairly convincing. The figures seemed to warrant the conclusion that the percentage of reduction of B.O.D. of the sewage applied to any given filter is not substantially affected either by the strength of that sewage or its rate of application up to the limits represented by the data. Since, however, Ohio studies of filter performance, and tolerances to loadings, have shown the limitations to continuous loadings but the remarkable capacity of trickling filters for super-loadings for periods of days or even weeks at a time.

High Rate Filtration

For upwards of ten years Levine and his associates at Ames, Iowa, have conducted studies of the trickling filter process. In the more recent past they have experimented with creamery and packing house wastes as well as with domestic sewage, with various types of filter media including specially devised ceramic shapes, with various dosing cycles, and with filters arranged to demonstrate the effect of bottom ventilation. Their findings are too comprehensive to be recited in any detail here. But it is perhaps of particular interest to note their findings with very high rate applications of domestic sewage having an average B.O.D. value of 226 p.p.m. Their filter constructed of 1-inch Raschig ceramic rings in 6-feet depth, when dosed at the rate of 16 million gallons per acre per day, effected a B.O.D. removal of 89.6 per cent, provided the filter discharges received efficient settling for one hour. Under similar conditions 1-inch to 3-inch crushed granite rock effected a removal of but 78.6 per cent. At application rates of 2 M.G./acre/day the B.O.D. removal per acre foot by filtration alone, with all types of filter material, was found to lie between 350 and 420 lbs. per day. At rates of 16 M.G./acre/day the removal increased to between 2,180 and 2,560 lbs. per day. With the advantage of 1 hour's settling of the filter discharge in Imhoff cones the B.O.D. removal per acre foot per day rose from 450 to 3,950 lbs. with granite rock of the size above stated and from 469 to 4,500 lbs. with 1-inch Raschig rings, when the rate of application was increased from 2 to 16 million gallons per acre per day.

Since June, 1934, Halvorson and his colleagues at the University of Minnesota; since September, 1935, Mohlman at Chicago; and Jenks during the past two or more years in California, have conducted experiments on high rate trickling filtration. Halvorson and Mohlman have also investigated the effect of recirculation of a portion of the effluent. With the Chicago sewage Mohlman could find little advantage from recirculation. Jenks' experiments have included both single and double stage filtration with preliminary settling, intermediate and final storage and settling, and high ratios of return effluent to the raw sewage treated. All of these experiments clearly demonstrate an increased rate of B.O.D. reduction per acre foot of material as the rates of application are increased to the filter beds.



Cleveland's Southerly Plant. Unique Clustered Sludge Digesters (Left); Imhoff Tanks (Center); Sprinkling Filters (Right). Betterments Include Bio-Flocculation, Involving Tapered Aeration, Ahead of the Filters. In the Digesters Sludge Pumped from the New Easterly Activated Sludge Plant Will Be Digested.

Jenks reports that at Salinas single stage filtration of settled sewage having a B.O.D. value of approximately 100 p.p.m. gave a reduction of about 77 per cent (860 lbs. of B.O.D. per acre foot of filter material) when the net rate of application of sewage was 4 million gallons per acre per day. Settled sewage having a B.O.D. value of about 116 p.p.m., when applied at the rate of 24 million gallons per acre per day, yielded an effluent having a B.O.D. value of 32 p.p.m. The removal was 72 per cent, representing 5,600 lbs. per day per acre foot of material as compared to 860 lbs. at the lower application rate.

Reviewing eight months of operation of the experimental high rate trickling filter at Chicago, data reported by Mohlman show that this filter, 8 feet in depth, operated at a rate of about 20 million gallons per acre per day. Although treating a comparatively weak Imhoff tank settled sewage, it yielded an effluent whose B.O.D. value ranged from 13 to 44 p.p.m. and in which the suspended solids ranged from 20 to 36 p.p.m. after one hour's secondary settling. The average B.O.D. removal effected by this filter during the period in question was 3,600 lbs. per acre foot per day. Mohlman calls attention to the fact that high rate trickling filters operate as biological flocculators in marked degree and improved final settling would admittedly have yielded superior results to those obtained at Chicago.

The predominant practice in Great Britain and on the Continent is to employ mechanical distributors for the application of sewage to trickling filters. These are of both the rotary and the reciprocating type. The use of these types of distributors is extending rapidly in America. With the high rates of filtration now under investigation it is mandatory that the dosing cycles be very short. This fact implies extreme care in the selection of type and in the design and functioning of dosing equipment.

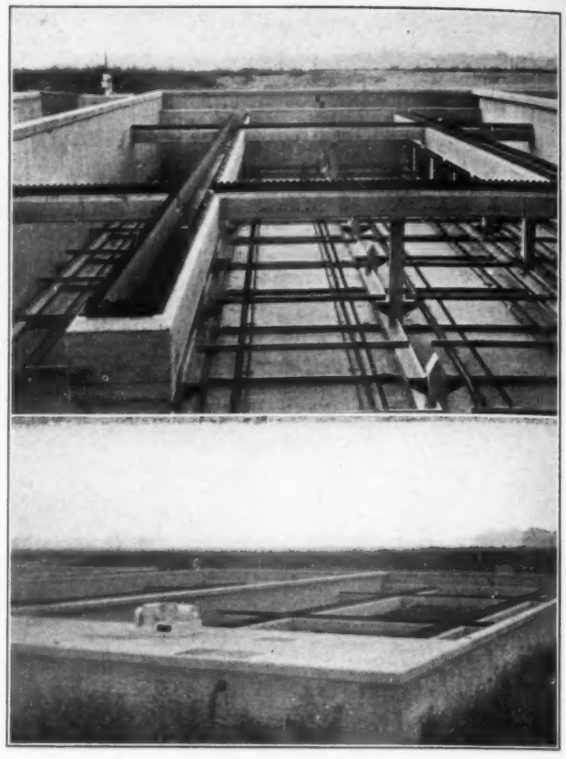
The control of filter flies has been a serious problem at some trickling filter plants. Experience has shown that reasonable control may be effected by flooding. High rate dosing gives promise of eliminating, or at any rate reducing fly nuisance.

The use of chlorine to overcome ponding of trickling filters is perhaps too well known to require more than this reference to its application for the purpose.

Activated Sludge

Thanks to the truly immense amount of basic laboratory research conducted during the past few years and to the great fund of practical operating experience which has accumulated, the activated sludge process has gradually become better understood and the practice correspondingly improved. Less is heard, for instance, in regard to sludge bulking troubles, probably because some sort of control by empirical methods if not by highly scientific formulas is now generally possible.

Nordell in 1917 pointed out that activated sludge "absorbs oxygen from the water just as rapidly when there are only a few parts per million in solution as it does when the water is almost saturated." He further stated "that the oxygen is absorbed three times as rapidly when the tank is first filled as it does 90 minutes later and four times as fast as it does 3 hours later. This would make it appear that the first tanks in a continuous flow series might well receive a greater proportion of air." He and others have found that the rate of oxygen absorption by a sludge and the rate of its purification are in almost direct proportion to its concentration in the aerating mixture.



The Take-Off Trough Arrangement in Columbus' Final Settlers. (The Camera Was at the Inlet End of the Tanks.)

Tapered aeration has become an accomplished fact. The short-period aeration tanks at the Southerly Works at Cleveland have been particularly designed to recognize the decreasing need of oxygen as the sewage progresses through the tanks.

In spiral flow design, which has been generally adopted for the larger installations, air is employed to satisfy the biological requirements and to maintain a velocity of movement of the sewage such that no putrescible solids will settle. The volume of air utilized for the first named function is small; that for the second relatively very large. The production of compressed air can never be made a highly efficient mechanical process. It would therefore appear to be a fundamentally more rational procedure to supply the air required for biological purposes by aeration, and directly through mechanisms to supply the energy to maintain the necessary travel velocity. This is being done with apparent economy in the Imhoff paddle and air diffusion combination method, first employed at Essen-Rellinghausen and since at several American plants.

Mechanisms, alone, are being depended upon in many of the smaller activated sludge plants and in some of fairly large size, notably in England. A variety of equipment has become commercially available. Among these are to be found the Simplex aerator, the Haworth Sheffield paddle, the Hartley Spiro-flow aerator, the Kessener (Holland) surface brush aerator; and, the American Well Works, Chicago Pump Company's, Dorr Company's, and Link-Belt aerators. It appears that all of these can perform the service for which they are intended, the important element to consider being the power demand per unit of purification accomplished.

It has always been a problem to secure rapid and efficient clarification of activated sludge by secondary settling. Various efforts have been made to increase the specific gravity of the suspended particles and thus speed up and improve the efficiency of the clarification

process. The beneficial effects of red clay added to the Charlotte, N. C., sewage was some time ago demonstrated by McConnell. Recently Whitehead and O'Shaughnessy at Birmingham, England, have shown that red marl, added in the amount of 25 per cent of the weight of dry solids in ordinary activated sludge, will greatly improve its settleability producing a remarkably brilliant effluent and yielding a sludge which settles rapidly to a dense and well compacted mass. The clarifying power was still further improved by adding a like amount of calcium carbonate. They conclude that the gelatinous mass of an activated sludge floc serves as a web or net capable of arresting fine particles floating in sewage. If the particles are organic the bacteria will feed upon them but if they are inorganic in character the bacteria will grow upon them and thus produce a heavier floc. [This reasoning would indicate a probable value of such material as powdered carbon, which has an enormous surface area and high adsorption value.]

Nolte, Meyer and Fromke have announced that if phosphate-ammonium-carbonate be added to activated sludge, then such substances as milk and starch wastes, acetic and lactic acid, etc., are completely decomposed and it becomes possible to grow a specific culture in the activated sludge capable of breaking down various organic constituents of waste waters.

At Indianapolis Calvert has demonstrated that plain aeration (bio-aeration—without sludge return) has continued to remove a greater weight of B.O.D. from the complete sewage contribution than was possible with the activated sludge process under imposed conditions, wherein bypassing of some of the settled sewage was imperative to maintain satisfactory acceptable activated sludge performance.

Intermittent Sand Filtration

In glacial drift regions and wherever suitable porous deposits are to be found, the final treatment of sewage by intermittent sand filtration is distinctly worthy of most careful consideration for institutions and smaller isolated communities. Such effluents are normally stable and require no further clarification. They are readily amenable to disinfection by chlorine compounds with comparatively small dosages. Effectively settled domestic sewage may be treated on well prepared and properly maintained beds at a rate as high as 200,000 gallons per acre. It appears that, all things considered, the best results are to be had with repeated dosing on one or two beds, throughout a 24-hour period, rather than allowing two long periods of rest between applications.

A Little Gem in Its Setting in the Bend of the River. A Splendid Example of What Beautification Does for Sewage Works as Well as Water Works. Every Sewerage "Salesman" Should Find This Picture of Geneva's (Ill.) Plant Worth Possessing.

Rapid Mechanical Filtration

As an adjunct to plain and coagulated subsidence and occasionally also of the activated sludge process and of trickling filtration, rapid filters (strainers) are finding a field of application. They are capable of serving a dual purpose. This purpose is partly esthetic as related to improved appearance and partly physical and biochemical in that suspended solids and B.O.D. are thereby further reduced. Specifically, such filters are capable of removing pin-point floc resulting from chemical treatment and the residual floc in effluents of secondary settling tanks of activated sludge and trickling filter plants. Thus, it is, that their presence assures a more uniformly satisfactory and consistent effluent. They may be applied to raw sewage in some cases in lieu of some other sort of pre-treatment; also to plain settled sewage to effect some further improvement, continuously or ad-interim with chemical treatment. In any case their use adds flexibility to the percentage performances of plants under the circumstances just enumerated. It seems likely, also, that their use will bring greater operating economy to the activated sludge process in air savings without too much consideration being given to bulking phenomena. Economy to chemical precipitation in the reduction of chemicals requisite for most efficient clarification. Economy to sprinkling filters, wherein high rate application of sewage is involved.

Although filters of sand and crushed anthracite have been suggested, it appears that but few, involving rapid water filter design and operation, have been employed in sewage treatment. However, for use with shallow sand or anthracite filters the Blaisdell type filter washing device is applicable, as has been suggested by Streander and others.

It is believed that the only straining type gravity filter, yet made commercially available for the purposes above described, is Filtration Equipment Corporation's Laughlin Magnetite Filter which is now being accorded a deserved acceptance. Originally this equipment was devised for upward filtration only and was made a structural part of circular settling basins operating with or without chemical coagulation. It was first introduced into the Dearborn plant and since further studied and improved. Within the past year independent downward flow units have been developed which bid fair to find a considerable field of usefulness both in sewage and industrial waste treatment. The earlier upward type of filtration has been installed also at Goshen, Ind.; Perth Amboy, N. J., and elsewhere. The independent downward type is involved in the design of the Cleveland (Southerly Works), Denver and the Minneapolis-St. Paul Sanitary District plants, under construction.

The operation rates of all types of rapid filters suggested for application to sewage treatment are about the same as those of standard rapid sand water filters, except that for periods of short duration higher rates appear practical.

The anthracite mat or blanket proposed to be used on Riensch-Wurl screens at Niagara Falls is a novel idea, apparently intended to approximate the effect of rapid filters when such effect is desired. The practical operation of these screens with their imposed mats of combustible material, some of which is scraped off with the solids to be incinerated, will be watched with interest.

Sludge

For many years the matter of sludge treatment and

disposal has been under investigation and observation. Even so, the very considerable amount of attention which it has received has probably not been as much as merited. Next in importance to the innocuous disposal of treatment plant effluents is assuredly the inoffensive and sanitary disposal of the solid material removed by the treatment process. Progress has been continuous in all phases of sludge treatment and disposal. In general, also, the rate of advance has been reasonably satisfactory. The ordinary methods of concentration, digestion, dewatering, grinding and disposal as fill or fertilizer have been abundantly exploited and are well known to those who can claim any real acquaintanceship with this field. The economics of sludge treatment and disposal have been comprehensively covered in a valuable way by Anthony J. Fischer in the March, 1936, issues of *Sewage Works Journal* and WATER WORKS & SEWERAGE. His contribution, presented before the New York State Sewage Works Ass'n in January, 1936, represents an intensive and worthy study of the subject, and is perhaps the first single paper in which the major factors in the problem have been simultaneously reviewed from the cost standpoint.*

Digestion—Dewatering—Incineration

Taken by and large the digestion of sewage sludges represents the most important phase of sludge disposal, because it is more extensively utilized than any other procedure. However, fresh sludges, resulting from both plain and coagulated settling, and activated sludge may be dewatered effectively by conditioning and vacuum filtration, by drying on beds, open and glass covered; and perhaps, though the evidence is less clear on this point, by centrifuging. Mechanically dewatered sludges are now being incinerated in several cases or being further dried for fertilizer production. For determining the extent to which digestion is being utilized in the treatment and disposal of sewage sludge in general, particularly of activated sludge, reliable statistics seem to be lacking.

Basically correct in principle, stage-digestion is steadily gaining in popularity. In most cases two stages are being adopted in preference to more, although excellent results in a remarkably short digestion period have been reported by Rawn from 4-stage digestion at the activated sludge plant of the Los Angeles County Sanitation Districts. The quality of gas produced in the first stage is practically that of gas taken from the fourth stage.

Recent semi-plant scale experiments on two-stage digestion by Cleary have suggested that there are certain advantages incident upon employing a primary period of thermophilic (130° F.) digestion followed by one of mesophilic (80°-84° F.) digestion. In his experiments, digestion time was reduced to 12 days and 75 per cent of the total gas volume was found to be produced in the second or mesophilic stage. His observations led him to conclude that a combination of thermophilic and mesophilic digestion effects a greater destruction of organic matter than does mesophilic digestion alone. He advocates the use of adequate stirring equipment and inoculation of the added sludge with ripe sludge; also the pre-heating and concentration of the fresh sludge.

To Stir or Not to Stir

The matter of stirring or circulating sludges in single stage digestion tanks remains a moot question. There are those whose experience leads them to believe that stirring is unnecessary if not actually disadvantageous; there are others who believe that practically continuous stirring is economical and otherwise of advantage: and there are still others who feel that occasional stirring only, mainly when fresh solids are being added, represents the best procedure.

It has recently been announced in Germany that stirring in sludge digestion is disadvantageous until methane producing bacteria have been developed and that thereafter stirring should be employed only to insure complete mixing of the added fresh sludge with the contents of the tank. Experiments carried out at Manchester, England, indicate that no marked advantage is gained by continuous circulation of digesting sludge in tanks operated at 77°-86° F. as compared with circulation for about 30 minutes daily immediately following the addition of fresh sludge. These studies suggest, furthermore, that the continuous withdrawal of sludge has no advantages over bulk daily withdrawals.

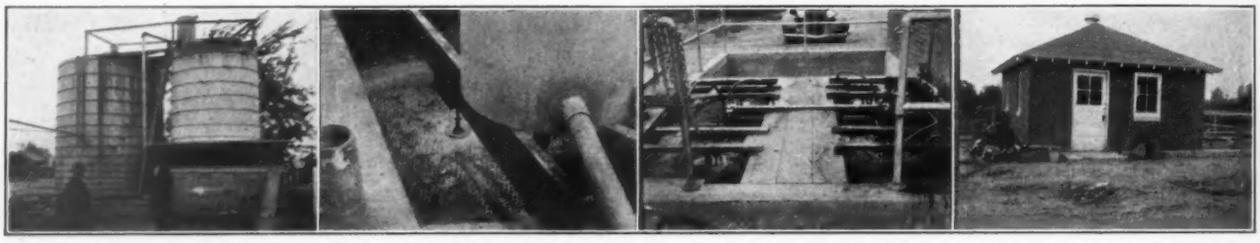
Walraven states that foaming in digestion tanks, newly placed in service, can be largely prevented if they are partially filled with actively digesting sludge and if fresh solids are added at a rate not exceeding 10 per cent of the solids in the tank. In any event fresh material should be added sparingly at the outset.

The effect of activated carbon in sludge digestion has already been referred to. Briefly stated, it has been reported that activated carbon may improve sludge digestion by increasing the temperature and gas production, by reducing the amount of carbon dioxide in the gas, by reducing or eliminating the odors of freshly drawn sludge.

Elutriation

Genter, Keefer and others have demonstrated the effect and value of elutriating digested sludge (washing and decantation) in preparation for dewatering by vacuum filtration. They have shown that digested sludges contain large amounts of amino-ammonia nitrogen and

Which Will Win?



Two Plants Treating Wastes from Neighbor Milk Products Plants. (1 *and* 2) *Holding Tank and High Rate Trickling Filter in Indiana;* (3 *and* 4) *Aero-Chemical Precipitation Plant Just Across the Line in Ohio.*

*[Note—For his contribution, Mr. Fischer was voted the Kenneth Allen Memorial Award for 1936 by the New York State Sewage Works Association.—Ed.]

that the amount of coagulant (ferric salts) required for conditioning is closely proportional thereto. It appears that dosages of ferric chloride may be materially lowered through the elutriation process of washing inhibiting compounds out of the sludge, regardless of what these buffering materials may be. It is only very recently that elutriation, as a process in sludge preparation, has moved from the laboratory to the operating plant stage. The process has been incorporated in the treatment plant plans of Baltimore (Back River and Patapsco Works), Atlanta, Greensboro, Hartford, Los Angeles, San Francisco, Washington and Winnipeg, and is being seriously contemplated at Columbus, Coney Island and Detroit.

Sludge Concentration by Heat

A limited number of laboratory experiments lately performed by Gregory at Palo Alto have indicated that the heating of plain settled raw domestic sewage sludges to temperatures of from 85 to 105° F. greatly assists their concentration. The raw sludges used in the experiments contained from 92.6 to 93.6 per cent moisture and from 69.4 to 74.5 per cent volatile solids. After heating for 3 hours at 86° F. the volume of substrate water constituted from 30.5 to 38.0 per cent of the original sludge volume. After 3 hours at 104° F. these values ranged between 40.0 and 43.0 per cent. The figures above given are to be compared with 10.5 to 15.5 per cent observed with unheated sludges. The water which separated from the heated sludges was much clearer than that from the unheated sludges. In all cases there was a sharp line of demarcation between the substrate water and the concentrated sludge in the heated samples. After three hours of heated storage the sludges began to bulk to an extent which tended to offset the value of heating.

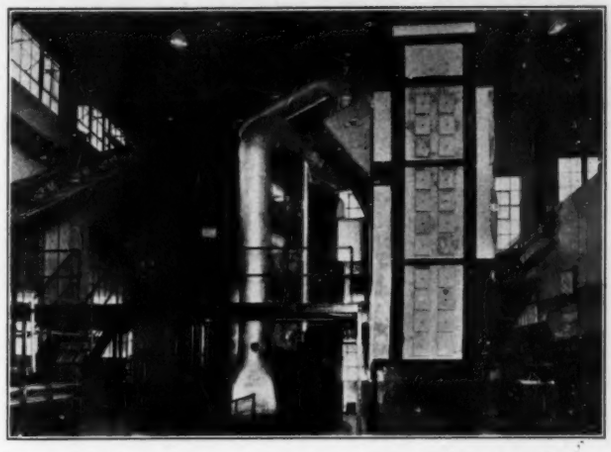
Experimental experience with the Porteous Process in England indicates that if plain settled raw sludge is heated under pressure to a high temperature it can subsequently be dewatered by filter presses without chemical conditioning in from 4 to 6 per cent of the time required for dewatering unheated sludges. The separated liquor is reputed to be odorous and to have a brownish-yellow color. The resulting filter cake is said to be hard, to have no unpleasant odor, but to be suitable for use as fuel or fertilizer. It is of interest to note that a separation of liquid and solids takes place during heating to such extent that two-thirds of the original sludge volume may be withdrawn as a liquor.

The development and use of centrifuges for the dewatering of sewage sludges is progressing slowly in Canada and in the United States, and abroad. Ultimately a comparatively high degree of success with this type of equipment may be achieved.

Hussey, Row and Allison at the Virginia Engineering Experiment Station have made some interesting observations of excess gas production ascribable to waste paper added to sewage sludge undergoing digestion. They found that 5.2 cubic feet of methane gas were produced per pound of paper added. The results of these experiments suggest that waste paper pulp added to sewage to improve flocculation or filtration should prove of subsequent value in terms of an additional available gas supply.

Sludge Gas to Power

In 1921 a 32 b.h.p. experimental gas engine was installed at Birmingham (England) to test the utility of digester gas for power generation. This experiment seems to have been antedated in Bombay where James



This Multiple Hearth Furnace at Dearborn Established the Possibilities of Sludge Incineration for Moderate Sized Plants.

is reported to have operated a gas engine on digester gas in 1907. The Birmingham tests were so successful that in 1926 a permanent installation was made of a 150 b.h.p. gas engine. Two other and larger units have since been added, one in 1929 and one in 1930. The three gas engines have a total capacity of 950 b.h.p. forming perhaps the largest operating power plant of its kind in the world. The practical and economic value of gas utilization for mechanical power purposes has been demonstrated under American conditions by Walraven, Piatt, Rawn, and others. Power production is now becoming an increasingly common undertaking at numerous treatment plants where sludge digestion is carried on. One engine manufacturer has alone made 24 recent installations and there are easily triple this number now in service, with many others contemplated. America's largest operating installation of three 300 H.P. units is at Coney Island and Washington is installing a 1,000 H.P. unit. Springfield, Ill.; Durham, Peoria and Los Angeles County continue to secure well-paying returns on earlier installations of gas engines.

The value of various types of sewage sludge for fertilizer purposes is being demonstrated. As a by-product sand bed dried sludges are being sold apparently at a profit. De Turk states, however, that the fertilizer value of activated sludge is barely sufficient to permit converting it to a dry fertilizer; but the cost of processing may in some cases be sufficiently low to permit of a slight profit to the producer.

Incineration

The successful incineration of moist sludge cake direct from vacuum filters in the multiple hearth type Nichols-Herreshoff furnace at Dearborn, Mich., at costs below original estimates and guarantees of the manufacturer, has been responsible for the growing interest in this method of destruction (thereby, complete disposal) of sludges. Large scale carefully checked experimentation by the Chicago Sanitary District with Combustion Engineering equipment led to the decision to adopt sludge incineration as Chicago's method of disposal, in preference to fertilizer production. As a result of these two developments several plants have had incorporated in their design sludge incineration. Milwaukee having earlier adopted the practice of incineration of centrifuged coarse and fine screenings and grit, and Los Angeles and Westchester County the incineration of partially dewatered (squeezed) fine screenings, a trend toward combination incineration of garbage and sewage solids has also been noted in several instances. For

sludge incineration alone 15 or more sewage plants are being equipped with incinerators especially adapted to sludge burning without odor nuisance.

In this connection the new and successful power producing garbage incinerator adjoining the Providence, R. I., activated sludge plant, and which supplies more than the power required to operate pump-station and treatment plant, is worthy of note and attention as a unique and practical and economic combination in wastes disposal management and operation. New York City has also recently completed the first of its garbage-rubbish incinerators, designed and operated to produce power on a paying basis—more particularly as a demonstration which has procured a reduction in rates charged the city by the power interests to a figure approximating that of production by the municipally operated destruction plant.

High Temperature Odor Destruction

It has long been recognized that odors of organic origin can be destroyed by exposure to high temperatures; i.e., in the neighborhood of 1200° F. Such temperatures are sought, for example, in connection with incineration.

The exhaust gases from the rotary-kiln-type drier producing fertilizer from activated sludge at Pasadena have been of a nature difficult to deodorize except at continuously high temperatures not substantially lower than the value above stated. For several years, these gases, amounting to about 15,000 cubic feet per minute, were deodorized with partial success by passage through a specially designed gas-fired furnace. The cost of maintaining a completely successful odor destroying temperature was found to be almost prohibitive. As actually operated, the annual cost of fuel for deodorization has been $6,654 to $7,200, while the cost of fuel for drying the sludge was $7,360 to $7,404. It will be seen that the fuel costs for odor destruction approximated those for drying, yet without entire freedom from complaints.

In November, 1935, a Royster-Cottrell stove type of deodorizer was placed in service and has been in continuous operation since that time. From the beginning it has proved a practically complete success from both the standpoint of odor destruction and that of cost. The cost of the installation, including considerable preliminary experimentation expense, was less than $20,000. It could be duplicated for perhaps $16,500, including the preliminary spray washing towers provided to remove a large volume of dust discharged in the drier exhaust gases. The net saving in operating costs due to the new installation, has been found to be $4,800 per year, an amount sufficient to amortize the cost of the installation in about 4 years. On top of this, odor destruction is essentially complete.

Stream Pollution Control

Very remarkable results in river conservation work have been achieved under the direction of conservancy boards, variously titled, in England and Germany. It is heartening to view their accomplishments in pollutional control and it is hoped that similar boards may be appointed with equal wisdom and that equally effective measures may be invoked for the control of pollution of streams in the United States.

During the past three or four years the whole problem of our National water resources including the conservation of streams has received the consideration of the recently created National Resources Board. A Special Advisory Committee on Water Pollution has made an investigation and report to the Water Planning Committee of that Board.

It is encouraging to observe that some cooperation between the states is being brought about for the purpose of accomplishing certain conservancy programs. For example, the three states, New York, New Jersey and Connecticut, have entered into a compact for the control of the pollution of shore waters. A compact for the cleansing of streams in the Ohio Basin, which is now in process of formulation, will be watched with keen interest in view of its great significance if proven workable on so large a drainage basin.

The treatment of sewage of communities along the north shore of New Jersey has effected a notable improvement in the character of the coastal waters. An excellent study of the water conditions between Long Branch and Point Pleasant, New Jersey, reported by the New Jersey State Department of Health, has revealed the true effectiveness of primary treatment and chlorination for the attainments desired.

Cole and Warrick of the Wisconsin State Board of Health have recently made some important contributions to the available knowledge concerning the oxygen requirements of fish life and the effects of pulp and paper mill wastes on fish.

Degrees of Sewage Treatment Requisite

The extent to which sewage should be treated in order adequately to protect a given stream against excessive pollution has not in the past been a readily determinable matter. Local conditions, primarily as related to the available volume of dilution water at critical stages or times, and the use to which that water is to be put, must of course determine the character of any effluent and that in turn the type and extent of treatment.

Thanks to the excellent research work carried on for many years at the Stream Pollution Investigations Laboratory of the United States Public Health Service at Cincinnati, at the laboratories of the Sanitary District of Chicago, and at other laboratories, and to the painstaking observations of stream loadings and resultant conditions at many places, the various factors are today fairly well known and the problem has become solvable.

Such solutions based on economic as well as technical analyses have recently been carefully worked out at several places in the United States including, for example, Chicago, Minneapolis-St. Paul, Columbus, New York City, San Francisco, Racine, Denver, Buffalo, Washington, D. C., and Detroit.

Obviously, in the interests of economy, provided the esthetic essentials are preserved, the self-purifying capacity of any receiving stream or other body of water and controlled dilution, where feasible, should be capitalized to the fullest rational extent, allowing a reasonabe factor of safety. This has been done in a very striking way under the Ruhrverband and Emschergenossenschaft in Germany, the West Riding of Yorkshire Rivers Board and the Thames Conservancy Boards in England. It is beginning to be done in America (notably at Denver and St. Paul-Minneapolis) and will be done more effectively in the future if river conservancy systems can be developed as is proposed for the Potomac drainage basin.

EXPERIENCES WITH FERRIC CHLORIDE AT EMPORIA, KANSAS

By S. F. KUNZ

Chemist, Water Department,
Emporia, Kansas

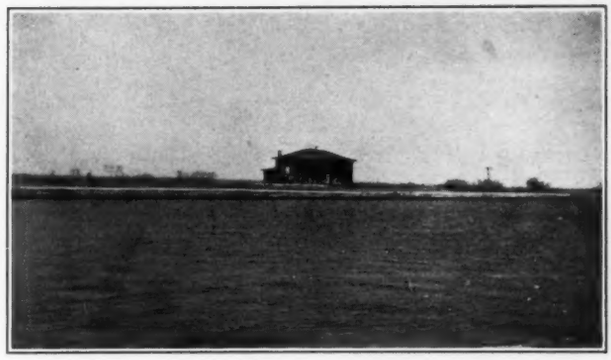
SINCE April, 1935, the municipal water plant of Emporia, Kansas, has been coagulating Neosho River water with ferric chloride instead of alum. The change was made after a laboratory study of the relative effectiveness of several commercial coagulants, including filter alum, copperas, chlorinated copperas, ferric chloride and sodium aluminate. It is thought that the indicated economy and operation improvements are of sufficient current interest to warrant this presentation.

The experimental work which led to the change to ferric chloride was inspired by frequently recurring periods of turbidities in the Neosho River water of such marked resistance to coagulation that excessive doses of alum were required to obtain satisfactory flocculation. These turbidities were very finely divided, being apparently of unusual dispersion stability. During these periods no doses of alum would produce an entirely satisfactory floc from the standpoint of sharpness of particle outline and clarity of settled waters. This resulted in the filters being called upon to handle an unusual quantity of poorly flocculated suspended matter in the applied water, with resulting shortened filter runs and a trouble making, persistent, objectionable taste common to insufficiently coagulated waters. Also noted, was an increased chlorine demand of the filtered water.

During these periods of maintenance of phenolphthalein alkalinity in the coagulation chamber and the substitution of copperas (ferrous sulphate) for alum afforded a measure of relief, but it was not always applicable, neither was it entirely satisfactory when applicable, since its complete precipitation required a narrow pH zone manipulation if residual iron in the effluent was to be avoided. It was for this reason that we did not consider the substitution of copperas (ferrous sulphate) for aluma satisfactory solution of our problem.

Preliminary Laboratory Work

Details of the laboratory work are obviously of secondary importance to the operating data and, therefore, in the interest of brevity they are not recorded in this discussion. The behavior of the aluminum containing coagulants was found to be satisfactory except when these "silky" turbidities were present. Sodium aluminate, used in conjunction with alum, offered a measure of relief but the improvement was not sufficient to warrant a plant scale experiment. Chlorinated copperas (i.e. ferrous sulphate to which has been added a quantity of chlorine sufficient to complete the reaction— $6FeSO_4 \cdot 7H_2O + 3Cl_2 \rightarrow 2FeCl_3 + 2Fe_2(SO_4)_3 + 42H_2O$) and ferric chloride were so unbelievably effective that a study was made as to the feasibility of using them.



A View Across the Clear Water Reservoir and Settling Basins—Emporia

The rapidity of floc formation with ferric chloride and the lack of sufficient chlorinator capacity to feed the additional chlorine required to produce chlorinated copperas, caused us to decide in favor of using crystal ferric chloride. Later we found that a substantial saving on freight charges could be obtained by purchasing it in the completely anhydrous form.

Comparative Results With Alum and Ferric Chloride

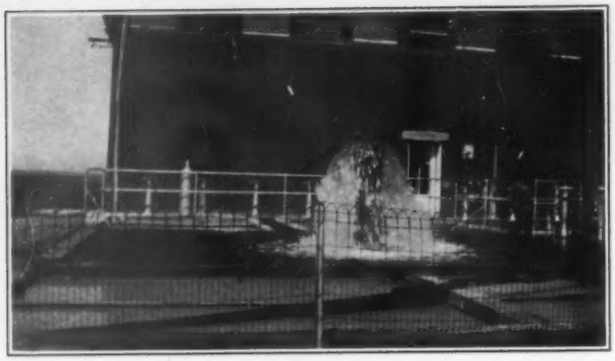
The change of coagulants has in general resulted in improved operation, decreased costs and a quite pleasing lessening of the heretofore worries during the unusually turbid periods of the Neosho. We have used less wash water, enjoyed a lower chemical treatment cost per million gallons and have, we believe, given our people an improved quality of water by using a ferric coagulant to replace alum.

In support of these conclusions that part of the operating data pertinent to this discussion for 1933, 1934, 1935, and the first two months of 1936 are shown in Table 1. It is interesting to note that the wash water consumption has dropped from 2.2 per cent in 1933 and 2.3 per cent in 1934 to 1.9 per cent in 1935 and 1.3

TABLE No. 1—GENERAL OPERATING DATA JANUARY, 1933, TO FEBRUARY, 1936, INCLUSIVE

Year	Water Produced (M.G.)	% Wash Water	Hydrated Lime Pounds	Hydrated Lime Avg. p.p.m.	Alum Pounds	Alum Avg. p.p.m.	Ferric Chloride Pounds	Ferric Chloride Avg. p.p.m.	Turbidity of Raw Water (p.p.m.)	Bicarb. Hardness (Raw) as CaCO3	Bicarb. p.p.m. (Tap) as CaCO3	Total Chemical Cost per M.G.
1933	688.3	2.2	165,580	29	143,780	25	0	0	237	177	177	$7.01
1934	654.0	2.3	149,170	22	118,590	22	0	0	249	150	150	$7.34
1935	691.5	1.9	*281,390	49	54,375	**9.4	47,260	**8.2	361	167	124	$9.86
Jan., 1936.	63.9	1.3	56,250	106	0	..	3,600	7.7	70	212	157	$9.15
Feb., 1936.	74.2	1.2	127,850	200	0	..	4,442	7.0	12	283	105	$14.50

*Includes lime increases due to intentional greater degree of softening.
**Averaged for entire year although both chemicals not concurrently used.



Aeration Unit and Primary Mixing Tank in Foreground

per cent and 1.2 per cent in January and February, 1936, respectively. The lowest wash water recorded during the last eleven years of alum use was 2.2 per cent in 1932 and 1933, the maximum for the eleven years being 4.0 per cent in 1928 and the average 2.8 per cent.

In order to effectively precipitate the finely divided calcium carbonate present in the water applied to the filters we have adopted a split application of coagulants, whereby a small dose of coagulant is applied to the effluent of the settling basins. In Table 2 is shown a detailed fourteen months' study of the relative coagulation efficiency of alum and ferric chloride in both stages of coagulation.

It is interesting to note that in addition to coagulation improvement the use of ferric chloride resulted in an average coagulation saving of $1.42 per million gallons treated during the first twelve months of ferric chloride use.

Application of the Ferric Chloride

The primary mixing basin is equipped with over and under baffles and retains the water for forty minutes during normal plant flows. The softening lime application is made at the inlet end of this basin and the primary dose of ferric chloride to the effluent. The water is then conveyed to the settling basin through an open flume 300 ft. long. An improvised mix for the primary dose of coagulant was obtained by inserting six inch boards spaced ten feet apart in this flume, effecting therein a vigorous two minute mixing period. (This is usually sufficient to form the ferric floc but we plan to change the entire system of mixing and settling in the interest of economy and dependable operation.)

The settling basin is quite large, having a capacity of 7,000,000 gallons or 1.75 twenty-four hour operating days or 2.8 average operating days. The plant has four filters of 1,000,000 gallons per day capacity each.

The secondary mixing basin is a duplicate of the primary basin. The secondary dose of ferric chloride was first applied to the inlet end but later changed to a point closer to the filters in order to reduce the floc particle size passing through the floc tearing filter influent valves and thus avoid breaking the particles.

TABLE 2—COAGULATION DATA, 14 MONTHS, BEGINNING JANUARY, 1935

Month	Primary Coagulant	Secondary Coagulant
Jan., 1935	30 p.p.m. alum	8 p.p.m. alum
Feb., 1935	26 p.p.m. alum	6 p.p.m. alum
Mar., 1935	22 p.p.m. alum	5 p.p.m. alum
Apr., 1935	* 7 p.p.m. alum	7 p.p.m. alum
May, 1935	Experimenting—Data not included because not representative	
June, 1935	12 p.p.m. $FeCl_3$	2.1 p.p.m. $FeCl_3$
July, 1935	8 p.p.m. $FeCl_3$	2.0 p.p.m. $FeCl_3$
Aug., 1935	7 p.p.m. $FeCl_3$	2.2 p.p.m. $FeCl_3$
Sept., 1935	8 p.p.m. $FeCl_3$	2.3 p.p.m. $FeCl_3$
Oct., 1935	4.6 p.p.m. $FeCl_3$	2.1 p.p.m. $FeCl_3$
Nov., 1935	No primary coagulant used	1.8 p.p.m. $FeCl_3$
Dec., 1935	Nov. and Dec. account low hardness	1.4 p.p.m. $FeCl_3$
Jan., 1936	6.4 p.p.m. $FeCl_3$	1.0 p.p.m. $FeCl_3$
Feb., 1936	6.6 p.p.m. $FeCl_3$	1.37 p.p.m. $FeCl_3$

Total needed average alum dose—27.75 p.p.m.
Total needed average $FeCl_3$ dose—9.15 p.p.m.
Total alum cost @ $1.85 per 100 lb.—$4.26 per million gallons.
Total $FeCl_3$ cost @ $3.74 per 100 lb.—$2.84 per million gallons.

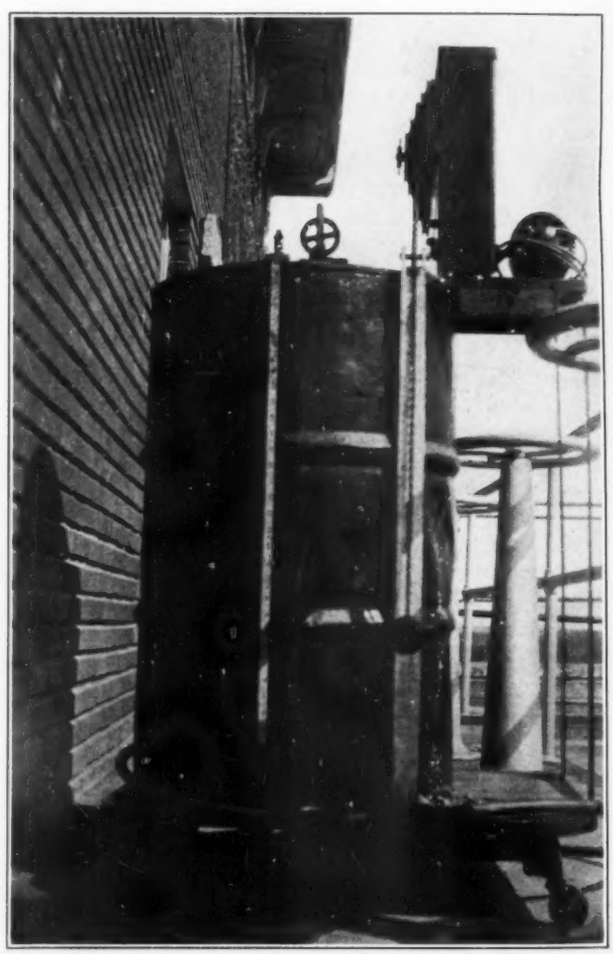
*Alum used part of month only.

Feeding Equipment

The excessive corrosiveness of ferric chloride has been considered a distinct objection to its use. However, by the exercise of a little ingenuity we were able to solve our problem economically.

The plant feeding equipment consisted of reinforced concrete solution tanks and two orifice type solution feeders. These feeders had been very unsatisfactory so no attempt was made to utilize them in ferric chloride service. Instead the alum solution tanks were protected from the ferric chloride solutions by one coat of bituminous paint and thick final coat of hot asphalt.

Dispensing at uniform and predetermined rates was accomplished through a flexible 1½ in. rubber tubing extending from the surface of the solution through the bottom of the tank to the point of application. The rate of feed control was regulated by the speed at which the hose tip was lowered. For this purpose a small electric motor actuated a system of reduction gears and



Our Portable Home-Made Ferric Chloride Solution Feeder

graduated pulleys from which pulleys the influent end of the hose was suspended by rubber covered wires. The submerged portion of the rubber hose was weighted in order to always keep it in its proper position.

With this rig the rate of hose tip lowering may be varied by changing the speed of the motor or the size of the controlling pulleys. By utilizing these variables, or varying the solution concentrations, any quantities of less than one pound and up to 10,000 pounds daily may be uniformly fed. At our normal rates of discharge we are able to maintain our desired dose within 0.2 p.p.m. $FeCl_3$ error.

A portable feeder mounted on rollers and operating on the same principle as noted above was constructed of a 50 gallon steel drum lined with asphalt, a second hand motor and pulley and a ½ inch discharge hose. It would feed up to 100 pounds per day and was very convenient for moving about the plant and for determining the most desirable point of secondary coagulation.

Effect on Quality of Water

Based on consumer reaction and the limited observations afforded by our laboratory equipment we are convinced that a measurable improvement has been made n the quality of the finished water.

Residual Coagulant in the Finished Water.—This had not been determined prior to the use of ferric chloride and, therefore, no comparative figures are available. Residual iron is one of the two bogeymen of the use of ferric coagulants in water plants (the other is feeding equipment) and we have checked this point as thoroughly as our laboratory equipment permits.

Qualitative tests on evaporated filtered water samples indicate insufficient iron present to give a positive reaction. At no time during the past twelve months have we received any complaint traceable to residual iron, neither have we visually noted any of the discoloration or cloudiness common to "irony" waters stored in open reservoirs.

Chlorine Demand of the Filtered Water.—This is perhaps a dependable index of the quantity of organic matter not removed by coagulation and filtration. Long term figures on average chlorine consumption are not applicable because prechlorination, started in 1933, has increased the quantity of chlorine used. Beginning with 1933 the chlorine required for pre and post chlorination has averaged 2.14 parts per million for 1933, 2.32 for 1934, and 1.88 for 1935. Water treated during the first two months of this year has required an average of only 0.53 parts per million.

Turbidity of Water Applied to the Filters.—This is included here as an indication of improvement in the coagulation phase of the treatment process. It averaged twenty parts per million with alum and has been reduced to five parts per million since the use of ferric chloride.

Tastes and Odors.—This is not a routine determination at our plant and a numerical contrast of the reduction in taste and odors is not available. We use activated carbon when, and in such quantities as may be needed. The actual amounts used have been 694, 739, 213, and 533 pounds for 1932, 33, 34, and 35, respectively. Potassium permanganate as an adjunct to copper sulphate has been found quite effective during algae troubles in the open clear water reservoir. Quantities used have been 270, 199, 508, and 700 pounds during 1932, '33, '34, and '35, respectively. Its use has substantially lowered the copper sulphate requirement, which averaged 216 pounds yearly during 1932-35 as compared with 3,462 pounds during 1924, 1,481 pounds in 1928 or 1,937 pounds in 1930.

We can definitely say that the taste and odor problem, as judged from consumer reactions, has been less intense during the past twelve months. This goes hand-in-hand with reduced chlorine demand, which in turn is indicative of higher removals of organic matter from the water and therefore taste producing substances.

Summary

The use of ferric chloride to replace alum has corrected coagulation difficulties recurring during periods of finely divided turbidity of the Neosho River water.

Its increased effectiveness is apparently due to its rapidity of floc formation in the presence of alkalinities encountered in softening plants.

The difficulties with alum may be ascribed almost entirely to inadequate floc forming periods and unsatisfactory velocity in our mixing chambers.

The alum solution tanks were adapted for ferric chloride use by successive applications of bituminous coatings and the home-made gravity feeder provided.

The use of ferric chloride has reduced drayage charges to less than half those of alum because of its concentrated form. The required storage space is also reduced proportionately.

Despite the double unit cost of ferric chloride ($3.74 per 100 lbs. delivered as compared with $1.85 for alum) a net saving is indicated in chemical costs of about $1.00 per million gallons.

The chemical and esthetic qualities of our finished water have apparently been improved, filter runs lengthened, and chlorine requirements reduced.

Acknowledgment.—The above paper was presented before the 9th Annual Meeting of the Kansas Water and Sewage Works Association, 1936.

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Beating Old Man River

One scheme of beating Old Man River in flood and drought is the scheme adopted at Catlettsburg, Ky. The car on the inclined track follows the river—up or down. On it are the raw water pumps. Paralleling the track

At Catlettsburg, Ky.

is the steam line "down-hill" and water line "up-hill." Both have connections spaced at frequent intervals and the mobile "pump-house" just goes up and down as the mighty or puny Ohio dictates.

EXPERIENCE WITH POROUS PLATES FOR FILTER UNDERDRAIN AT DENVER, COLO.

By O. J. RIPPLE
Supt. of Filtration,
Denver, Colo.

The Author

TWO of our older filter plants have round wooden tanks 12 feet in diameter arranged in pairs for filter units. The sand used for the filter material has an effective size of approximately .50 mm and a uniformity coefficient of 1.8 to 2.0 and is 20 inches deep. The sand is not supported by gravel but rests directly upon the false bottom, which contains perforated house screens 2½ in. in diameter, spaced 6 in. centers.

The cleaning of these screens has been a rather expensive maintenance job for years. It has also been necessary to replace some screens, screen rings and holders.

The screens in filters equipped with cast iron screen holders are usually cleaned each year and those having bronze screen holders every two years, the difference being due to rust from the cast iron screen holders.

The screens are cleaned by removing the sand and the screens; the screens are suspended in a solution of muriatic acid, then rinsed in ammonia water and replaced in the screen holders.

During 1935 we noticed, from accounts in various publications, that Aloxite porous plates were being used extensively in sewerage work and that a somewhat similar plate of Aloxite was being recommended by the Carborundum Company for use in filter underdrains.

We decided in the fall of 1935 that it would be advisable to experiment with these under-drain plates in one of the older plants to see if they would relieve the expense of cleaning the screens and also, by a more even distribution of the wash water, prevent "coning" in the filter sand and the accompanying evils of mud balls and cloudy effluent.

The South Side Filter Plant was selected as the most economical and practical plant for this experiment, as this plant has the most variation in turbidity and microorganisms in its raw water supply, and also has smaller filter units than those at the North Side Filter Plant. The source of supply is Marston Lake which has a capacity of 6,500 million gallons.

Plain Aloxite plates 1¼ inches thick and 11 13/16 inches square, with curved sections around the circumference to fit the circular tanks 12 ft. in diameter, were installed in the two tanks comprising Filter No. 2, and were placed in operation April 10, 1936.

Plain plates instead of ribbed plates were used in this installation to fit the old underdrain construction. The plates were supported on 2 in. by 4 in. timbers on edge spaced 12 in. centers both ways and were cut away at the corners to allow for ⅜ in. brass lag screws and washers. The space between adjacent plates was filled with an asphaltum compound furnished by the manufacturer.

Operating Data

The following table gives some operation data for nine months and shows a comparison of Filter No. 2 with Filters No. 1 and 3, the latter two being adjacent filters with perforated screen underdrains.

The raw water turbidity varied from 4.2 to 17.4 p.p.m. with an average of 7.5 p.p.m. The effluent water turbidity varied from .66 to 4.26 p.p.m. with an average of 1.53 p.p.m all being monthly averages. The high effluent turbidities were due to high rates of filtration used and to poor coagulation facilities at this plant.

The micro-organism counts in the raw water varied from 331 to 1,622 standard units per c.c. for monthly averages.

No separate record was kept as to the effluent turbidities of the three filters although some random samples indicated that the effluent from Filter No. 2 was somewhat clearer than that of Filters No. 1 and No. 3, the main object of the test in this case being to determine how long the Aloxite plates would continue in service without cleaning and the best method of cleaning the plates if they became clogged.

It is apparent from the table above that some clogging took place in August as shown by the per cent of wash water, this clogging was due, in part, to poor coagulation as this is an old plant and has a very short coagulation period.

Again in November the per cent of wash water for Filter No. 2 was higher than that for Nos. 1 and 3. An investigation revealed that the effluent valve had not been opened as wide on Filter No. 2 as the effluent valves on Nos. 1 and 3 and it was thought that operating at such a low rate the floc had made a heavy mat on the surface and thus caused the head loss to build up rather than being due to excessive clogging of the plates. However, draw down tests for the filter tanks compared with similar tests when the plates were installed, seemed to indicated some clogging in these plates.

Plates Treated with Caustic

It was thought advisable to remove the sand and treat the plates, in place, with a solution of sodium hydroxide. This was done the last week of November, 1936, we used a 3.3 per cent solution of sodium hydroxide and after 48 hours' contact the sand was replaced and the filter was washed thoroughly after another 24 hour contact period.

Ordinarily it would not seem to be necessary to disturb the sand but it was in this instance to allow an inspection to be made, to see if the plates appeared to be stopped up and to see how the plastic compound was holding between the plates. Some places had previously been found where the plastic compound had not thoroughly closed the openings between plates, but no sand had been lost because of the 2 by 4 strip under the joints between plates. The plates did not appear to be stopped up and the joints were found in good condition.

In future cleaning of these plates we have in mind

TABLE No. 1—SUMMARY OF FILTER RUN DATA

FILTER No. 1

Month	No. of Runs	Hrs. Run	Av. Run Hours	Av. Head Loss	MG Filtered	Rate MG per A Per D	Wash Water MG	Wash Water Percent
April	42	464.7	11.1	8.60	21.92	220	2.47	11.25
May	53	722.7	13.6	8.35	41.82	268	3.20	7.65
June	49	694.1	14.2	6.00	39.05	262	2.92	7.60
July	51	706.7	13.9	5.99	37.94	250	2.87	7.57
August	31	737.2	23.8	5.83	20.92	132	2.33	11.14
September	61	695.9	11.4	6.30	35.51	238	3.95	11.13
October	28	696.2	24.9	6.47	23.80	160	1.70	7.15
November	10	723.7	72.4	9.08	7.50	48	.61	8.10
December	8	724.8	90.6	8.39	12.23	79	.65	5.33
Total	333	6165.8	....	....	240.69	...	20.70	....
Average	..	685.1	18.52	7.22	.....	182	....	8.60

FILTER No. 2

(Aloxite Plate Underdrain)

Month	No. of Runs	Hrs. Run	Av. Run Hours	Av. Head Loss	MG Filtered	Rate MG per A Per D	Wash Water MG	Wash Water Percent
April	52	460.2	8.8	8.76	25.16	254	3.05	12.12
May	61	711.3	11.7	8.50	49.22	322	3.73	7.58
June	57	691.3	12.1	6.10	47.08	318	3.46	7.35
July	52	738.0	14.2	6.33	45.75	288	2.54	5.56
August	32	730.7	23.1	5.24	20.31	129	2.29	11.29
September	55	707.8	12.9	6.54	30.25	200	3.14	9.16
October	19	667.9	35.2	7.07	17.90	125	.94	5.25
November	8	605.5	75.7	8.46	2.87	22	.39	13.60
December	7	698.9	99.8	8.66	10.98	74	.51	4.59
Total	344	6011.5	....	....	249.53	...	20.06	....
Average	..	667.9	17.5	7.30	.....	194	....	8.04

FILTER No. 3

Month	No. of Runs	Hrs. Run	Av. Run Hours	Av. Head Loss	MG Filtered	Rate MG per A Per D	Wash Water MG	Wash Water Percent
April	36	473.3	13.2	8.57	22.07	217	1.95	8.83
May	46	711.3	15.4	8.26	41.62	273	2.83	6.79
June	40	665.8	16.6	6.10	37.46	262	2.43	6.50
July	48	703.5	14.7	5.96	38.05	252	2.74	7.19
August	28	738.6	26.4	5.67	20.75	131	2.13	10.25
September	54	682.3	12.6	6.34	34.34	234	3.60	10.48
October	23	692.1	30.1	6.34	23.77	160	1.41	5.93
November	8	599.4	74.9	8.87	6.21	49	.51	8.16
December	7	764.3	109.2	7.65	10.16	62	.55	5.41
Total	290	6029.5	.....	....	233.54	...	18.14	....
Average	..	669.9	20.8	7.08	.....	180	....	7.76

using a combination of chlorine and caustic soda as we feel that the caustic soda may not be sufficient to remove all of the foreign matter that may be collected in the porous plates. The chlorine solution will be used *after* the caustic soda treatment. In this way the alkali will dissolve what it can and thereafter the acidic and oxidizing chlorine what it can.

The results for December show a decided improvement in per cent of wash water used as compared with November, but not much of an improvement over the September and October figures.

From the data at hand, it would seem that the plates were not as badly clogged as we had thought when the per cent of wash water for November jumped up as it did, and that the cleaning was not particularly necessary at that time.

As previously mentioned we wished to try Aloxite plate underdrains to avoid uneven distribution of wash water which we have with our present underdrains. Our operation has shown that we did have a much more uniform wash, and relieved the mud ball situation.

This type of filter underdrain also does away with the necessity of gravel beds and allows the filter material to rest directly on the plates. This feature does away with the expense and trouble of keeping the gravel and the filter material separate, if it becomes necessary to remove these from the filter for any purpose. Our experience with these plates as a filter underdrain has been very satisfactory to date.

Summary and Conclusions

The first 9 months' operation with the Aloxite plates indicate that these plates will make a very satisfactory underdrain for filters, provided the raw water is properly treated and the filter material is of proper size and deep enough to prevent any appreciable amount of the suspended matter in the coagulated water or fine floc from reaching the plates.

The cost of installing the plates in these 12 ft. diameter filters (rated capacity 325,000 g.p.d. at 2 gal./sq. ft./min.) was $950.00. Naturally the cost was higher than for a rectangular filter of equal area, because the small plate sections around the circumference of the tanks cost as much as the larger square plates.

The above cost is somewhat more than the cost of our present underdrain systems of perforated screens, but if the expense of screen replacement and cleaning is reduced, as we hope it will be, the additional expense will be more than justified.

A FEW "KINKS AND GADGETS" IN THE OPERATION OF A WATER SYSTEM

*The Second of Two Articles**

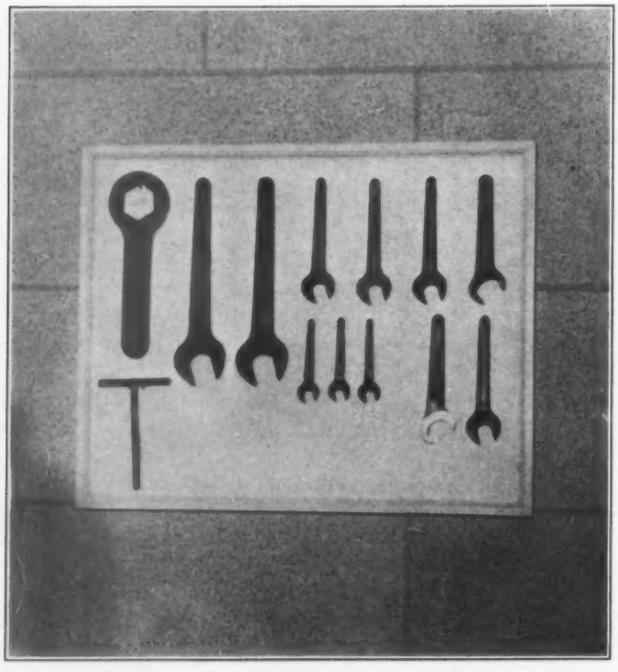
By CARL A. HECHMER
Dept. Engr., Washington Suburban Sanitary District, Hyattsville, Md.

Tool Boards

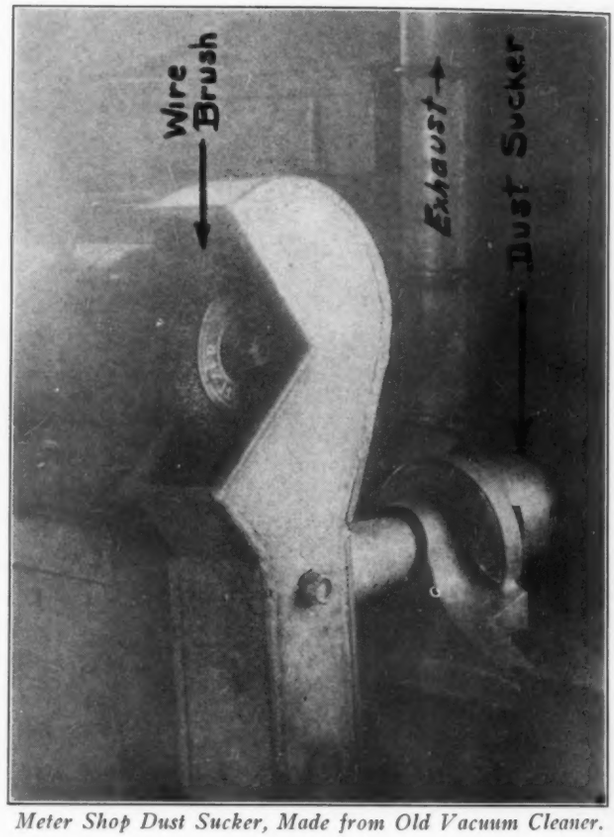
The Author

THE tool board is a very valuable asset to any pumping station. Necessary tools for emergency repairs are always in easy reach of the operator which eliminates delay due to lost tools. Having all the tools in plain view enables the operator to select the proper tool for the job at hand and thereby facilitates the repair. Tools will be maintained in proper condition for a broken tool on the board will soon be noticed and replaced before it is needed in an emergency. Also, the tools will be cleaned each time they are used. It is obvious that a tool box will not offer these advantages. The greatest advantage, however, is the prevention of lost or stolen tools. By painting the shape of each tool in the proper location on the board, any missing tool can be noticed at a glance and the size and type is readily determined. As shown on the pictures the tool board can be attractive and will not detract from the appearance of the plant.

*In the December, 1936, issue of "Water Works and Sewerage" (p. 467) Mr. Hechmer's earlier contribution revealing other "kinks" is to be found.—Ed.



Tool Board—with All in Place and in Good Condition



Meter Shop Dust Sucker, Made from Old Vacuum Cleaner.

Exhaust Fan for Cleaning Meter Cases

A use for an old ordinary household vacuum cleaner has been found in our meter shop. For some time the shop men complained of the dust, dirt and bronze paint flakes in the air when cleaning meter casings with a power brush. Covering the cleaning mechanic's nose with a protecting device proved of little value since the other men in the shop were also affected. Finally an old vacuum cleaner was hooked up in the same circuit with the switch controlling the motor which operates the cleaning brushes and the suction effect of this cleaner has entirely eliminated the trouble. Since the hood and exhaust pipe arrangements were fashioned by the men in the shop, little expense was involved in securing this very valuable asset to our meter shop.

Truck for Moving Chlorine and Ammonia Cylinders

Handling of heavy containers such as are used for chlorine and ammonia gas is a problem in plants where the floors are to be protected, and only one operator is available to move the tanks around. A platform truck 17 in. wide and 24 in. long supported on four large wheel castors is being used with considerable suc-

cess at several plants under the writer's supervision. The most important feature is the height of the top of the platform off the floor, for it should be exactly the same height as the scale platform on which the tank stands while it is being used. The full and empty cylinders in the storeroom must also be placed on a platform of the same height. The wheels of the truck are rubber tired which protects the floor surface and makes the truck easy to push around when loaded. One man can handle a 150 lb. cylinder of chlorine with this truck without difficulty.

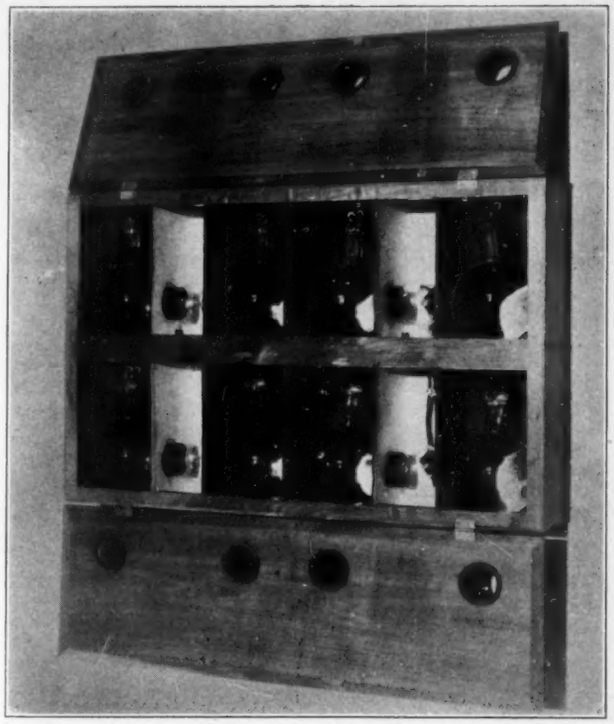
Cylinder Cradle

For carrying cylinders long distances over rough ground where the use of a truck is not possible, or for carrying a cylinder up flights of stairs when an elevator is not available, a cylinder cradle or "stretcher" has been devised as shown on the accompanying picture. Two men can handle a 100 lb. cylinder with ease while four men are necessary with larger tanks especially when going up a flight of stairs. Good secure hand holds are possible with this device and there is no danger of the cylinder being dropped and injuring the men. If an accident should occur the cradle will cushion the effect of the shock of the fall and there is less danger of a tank failure.

Pilot Lamp on Chemical Machines

In order to insure the operation of the dry-feed chemical machines at the Robert B. Morse Filter Plant, against failure due to electric trouble caused by power failure or blown fuses, we have installed a small electric lamp on each machine in the same circuit with the electric motor which operates the feeder. With several machines operating in the same room it is impossible for the operator to observe by sound whether any one machine is not operating especially when noise is caused by other machinery as well. To visit each machine frequently and open the observation door to determine when the feeder is in operation would require the continuous services of the operator and he would have no time for other duties around the plant. With the pilot lamp arrangement, the lighted lamp indicates just which feeder is in operation and the operator can tell at a glance if the motor has stopped. It is of course obvious that the pilot lamps must be located on each machine so that all can be seen from a central observation point.

Chlorine Cylinder on Scale Height Rubber Tired Dolly and Two-Man Cylinder—Cradle with Carrying Handles.



Sight Flask Box—Open, Showing Flasks for Observing Effluents for 8 Filters at a Single Convenient Observation Point.

Sight Bottle Boxes

Frequent observance of the filter effluents at any filter plant is most important. The use of a sight bottle installed at each filter has been published a number of times. With the variables eliminated, such an angle of observation, intensity of light and volume of observed sample, this device is indispensable in the modern filter plant. For the observation of the entire eight filters at the Morse plant, a sight box with four 250 watt lamps and eight 2 liter balloon flasks has been built. One switch turns on all four lights and the operator observes all filters each time he gets near the box. The sight box has been placed on the second floor of the high lift pumping station and must be passed by the operator going from the pumping station to the filters which are outside the building. Because of the convenient location the bottles are inspected very frequently. The operator need not leave the building to observe the condition of the filter effluents even though the filters are separate structures in the rear of the pumping station. Each filter effluent pipe was tapped and connected by one-eighth inch copper tubing to its respective bottle. The discharge from the bottle is carried by a similar copper tube to the basement of the pumping station at a point slightly lower in elevation than the filter effluent pipe and a siphon is thus created. The water is started by a small vacuum pump located at the discharge tubes in the pumping station basement.

THE NEWER METHODS OF SEWAGE WORKS FINANCING

Recent Experiences in the State of Illinois

By C. W. KLASSEN[1] and W. H. WISELY[2]

Illinois Department of Public Health, Springfield, Illinois

DURING the past two years there has been unprecedented progress in Illinois in the construction of sewerage works. An all-important factor in this program has been the turning to account by engineers and municipal officials of the progressive legislation enacted during 1933 for financing such works. The passage of the sewer revenue bond and service charge law in that year, followed by the combined water and sewerage revenue act of 1934, resulted in developments in sewerage financing which, so far as Illinois

The Authors

is concerned, are comparable in importance to the rapid advance in sewage treatment methods.

While some other states have benefited from "sewer rental laws" for some years, such legislation was undoubtedly hastened in Illinois when it became apparent that its communities could receive relatively little Federal aid for sewerage works under the then existing laws pertaining to municipal financing.

Previous to the past two years all sewage works in Illinois had been financed either by general obligation bonds or special assessment, while an occasional fortunate municipality would find sufficient money in the general fund to partly or entirely pay for sewers or treatment units. Both of the former financing plans have certain undesirable characteristics and limitations.

General obligation bonds must be approved by referendum vote and their issuance is limited within the constitutional provisions and limitations to 5 per cent of the assessed valuation of the municipality and by statute (with few exceptions) to 2½ per cent of that assessed valuation. Legislation, passed in 1936, allows Illinois municipalities of less than 5,000 population to increase the 2½ per cent debt limit to the constitutional limit of 5 per cent, provided the proceeds from the bond issue are to be used for sewerage improvements.

Special assessment bonds, as the name implies, are retired by assessments against the property—such being based on the benefits derived. Such bonds can be issued without approval by the electorate.

Sewerage revenue bonds, issued under the 1933 Sewerage Revenue and Service Charge Law differ basically from these other plans in that they are retired solely by sewer service charges or so-called "rentals" paid by the users of the sewer system, the amount paid being dependent upon a schedule of rates designed to apportion the charges according to the degree of service rendered. The revenue thus obtained must be adequate to operate and maintain the sewerage system, provide a depreciation fund, retire the principal and pay interest on the bonds issued. Delinquent bills for sewer service constitute a lien upon the property served. Approval of the issuance of sewerage revenue bonds by referendum is not a requirement. However, a referendum becomes mandatory if petitioned for, within 10 days after publication of the ordinance, by 15 per cent of the voters in the last preceding municipal election for the presiding official of the governing body of the municipality.

The combined water and sewerage revenue law is similar in form and administration to the sewerage revenue law, but under this plan the water and sewerage systems are thereby combined and operated as a single utility. Many advocates of the sewer revenue plan look upon this as a logical combination with the payment designated as a "utility charge." Both of the above service charge laws are applicable to cities, villages and sanitary districts of less than 500,000 population.

This paper is intended to partially, at least, meet the many requests of consulting engineers and municipal officials and sewerage authorities, from within and outside the State, for information concerning the interpretation and various adaptations of these sewer service charge laws, under individual and varied conditions, during the first two years of their existence. In short, to answer the question "How has the plan worked out on a practical basis?" Also, information is included relative to the financing of all projects involving sewage-treatment works which were placed under construction during the same period. Many interesting facts are brought out by a study of the tabulations.

Table 1 lists all sewage treatment projects (except those of the Sanitary District of Chicago) placed under construction during the period of July 1, 1934, to November 1, 1936. The nature of the projects, costs, extent of participation by Federal public works agencies and methods of financing are set forth. The most significant fact is that these 49 projects, involving a total expenditure of about $6,300,000, constitute by far the greatest progress in sewage treatment ever made in Illinois during any two-year period. In turn, the result in a large way is a commentary on activity by the State Sanitary Water Board, formed in 1929.

In Table 2, a summary of the methods of financing is presented. Among other things, this brings out the

[1]Chief Sanitary Engineer and [2]Assistant Sanitary Engineer.

TABLE 1
SEWERAGE WORKS FINANCING IN ILLINOIS
JULY 1, 1934 – NOV. 1, 1936

MUNICIPALITY	1930 POPULATION	NATURE OF PROJECT	FEDERAL PARTICIPATION	COSTS TOTAL	COSTS GOVT. GRANT	COSTS PORTION BY MUNICIPALITY	METHOD OF FINANCING BY MUNICIPALITY	REMARKS
Abingdon	2,771	C	L&G	$ 54,911	$ 18,911	$ 36,000	S.R	
Algonquin	866	C	L&G	48,136	19,636	28,500	W&S.R	
Aurora S.D.	47,000	A	G	88,700	26,460	42,240	G.F.	
Barrington	3,213	S-C	G	327,000	93,681	275,000	W&S.R	$34,000 old water bonds refunded
Batavia	5,045	I-2C	L&G	95,341	20,913	74,429	S.R	
Belvidere	8,123	I-C	G	251,000	112,500	138,500	S.R	
Bloom Twp. S.D.	23,000	C	G	(1) 300,000	81,000	219,000	G.O	
Breese	2,399	S-C	L&G	(1) 96,000	21,600	74,400	S.A.	
Carthage	2,240	C	None	32,129	None	32,129	G.O	
Cary	731	A	G	(1) 12,000	9,000	3,000	G.F.	W.P.A. project
Clinton S.D.	6,000	I-C	G	157,303	47,809	109,554	G.O. & G.F.	$22,554 from general fund
Danville S.D.	40,000	I-P	G	342,417	154,088	188,329	G.O.	
Dixon	9,908	I-P	G	263,636	118,636	145,000	G.O.	
Du Quoin	7,593	C	L&G	(1) 466,000	25,700	340,300	W&S.R.	$275,000 allotted to water project
Edwardsville	6,235	I-C	L&G	199,748	54,000	146,000	S.R.	
Effingham	4,978	A	L&G	51,538	23,727	23,000	S.R.	
Elmhurst	14,055	I-C	G	420,000	189,000	(2) 231,000	W&S.R.	
Flora	4,393	C	None	50,000	None	50,000	G.O. & G.F.	$27,000 from general fund
Gillespie	5,111	I-C	L&G	(1) 90,909	40,909	50,000	S.R.	
Hillsboro	4,435	I-C	L&G	88,500	22,500	66,000	S.R.	
Kankakee	20,620	I-C	G	366,636	150,136	216,500	S.R.	
Kewanee	17,093	C	G	210,000	91,636	120,000	S.R.	
Ladd	1,318	I-C	L&G	43,000	12,300	30,700	S.R.	
Lansing	3,378	C	L&G	(1) 65,454	29,454	36,000	G.O.	
Libertyville	3,791	C	None	(1) 45,000	None	45,000	S.R.	
Lincoln	12,855	I-C	G	208,800	94,500	41,220	S.R.	$73,080 contributed by State (3)
Litchfield	6,812	C	L&G	105,000	45,000	60,000	S.R.	
Macomb	8,509	C	G	94,538	25,000	69,537	S.R.	
McHenry	1,354	C	L&G	23,000	6,300	16,700	S.R.	
McLeansboro	2,102	S-C	L&G	75,727	32,727	43,000	G.O. & S.R.	
Monmouth	8,666	I-C	G	145,539	42,000	104,000	S.R.	
Mt. Morris	1,902	I-C	G	31,400	8,400	23,000	S.R.	
Nashville	2,243	S-C	L&G	98,181	44,181	54,000	G.O. & S.R.	
North Shore S.D.		I-P	G	(1) 869,000	238,000	631,000	G.O.	Waukegan project
Peoria S.D.	110,000	A	G	99,384	25,000	74,334	G.F.	
Pittsfield	2,356	A	None	28,200	None	28,200	S.A.	
Polo	1,871	C	L&G	37,800	9,800	28,000	S.R.	
Pontiac	8,272	C	G	159,109	69,900	29,000	G.O.	$60,407 contributed by State (3)
Princeville	994	S-C	L&G	56,526	14,723	41,803	G.O. & S.R.	
Red Bud	1,208	S-C	L&G	76,164	20,970	55,194	S.A.	
Rochelle	3,785	C	None	70,521	None	70,521	W&S.R.	
St. Charles	5,377	I-C	None	85,643	None	85,643	G.F.	
Salem	4,420	A	G	46,000	12,000	34,000	S.R.	
Springfield S.D.	75,000	A	G	74,549	33,600	40,949	G.F.	
Sullivan	2,339	S-C	G	177,712	80,180	(2) 97,532	W&S.R.	$39,850 allotted to water project
Sycamore	4,021	C	G	83,325	18,998	64,000	G.O.	
Waterloo	2,239	S-C	G	123,201	50,318	72,883	S.R. & G.F.	$21,383 provided from general fund
West Dundee	1,897	I-C	G	117,250	47,250	70,000	W&S.R.	$21,375 allotted to water project
Wyanet	859	S-C	G	61,500	23,545	37,945	W&S.R.	

— LEGEND —

Nature of project:
S – Sewers
I – Intercepting sewer
C – Complete treatment works
P – Partial treatment works
A – Additions to treatment works

Federal Participation:
G – Grant only
L&G – Loan and grant

Method of Financing:
S.R. – Sewerage Revenue
W&S.R. – Water and Sewerage Revenue
G.F. – General funds
G.O. – General obligation
S.A. – Special assessment

— NOTES —

(1) – Engineer's estimate, all others are final figures or are later estimates during construction.
(2) – Additional water and sewerage revenue bonds issued to refund old water bonds.
(3) – For service to State institutions.

part played by Federal financial assistance, because only 5 of the 49 projects were financed without such Federal aid, 43 being constructed under the Federal Public Works Administration, and 1 under the Works Progress Administration—familiarly known as PWA and WPA.

Prior to 1934, most of the smaller sewage treatment projects were financed by special assessment, because of the fact that the constitutional limit for general obligation bonds had been approached in financing water, for paving or other improvements. Table 2 now reveals that since July, 1934, only 3 special assessment projects appear in the 49 listed. It will also be noted that 4 of the projects financed by general obligation bonds were constructed by sanitary districts which are authorized to issue such bonds as a separate municipality regardless of the bonded indebtedness of any city or village within the sanitation district's boundaries.

The extensive use of the sewer revenue plan of "pay-as-you-use" is revealed when noting that this method of paying for sewage works and its operation was adopted by 31 of the 49 municipalities. In three instances (McLeansboro, Nashville and Princeville) general obligation bonds were issued to the constitutional limit and the balance needed was raised by issuing sewerage revenue bonds. Here are illustrations of another permissible use of the revenue plan and its flexibility in deriving the most practicable plan of financing, or one with the least cost. Turning to account this new legislation in most instances was considered as the only means remaining for legal financing of the projects, but more recently there has developed a better understanding of this plan in general. The result is the present trend toward following these modern methods of financing, as indicated by the definite preference for them by many municipal officials and engineers. Also another development of importance is the fact that these revenue bonds of the utility type are apparently becoming more attractive to the bond purchaser. At the present writing such bonds are, in fact, very much in demand at a premium. [The PWA has made a sizeable profit in the distribution of such bonds taken from municipalities as emergency loan security when the banking doors were closed to this same type of financing.—Ed.]

Financing by Sewerage Revenue

Detailed information concerning the application of the sewerage revenue act by the 23 municipalities using this plan is shown in Table 3. It is, of course, impossible to include complete rate schedules in such a tabulation because some of the schedules are quite complicated. While an attempt has been made to make the data as comparable as possible, caution is suggested in comparing rates, unless also taking into account the nature of the project financed, public benefit payments from the general fund and other such pertinent facts peculiar to some of these projects put through as emergency relief measures.

Although the revenue acts provide for a referendum, in only 3 of the 23 projects were referendums petitioned. However, 5 proposed projects, not listed here, have been temporarily delayed due to the fact that proposed bond issues were voted down in referendums. In most of these cases the paramount question was, however, not the undesirability of sewer revenue bonds, but

TABLE 2
SUMMARY OF METHODS OF SEWERAGE WORKS FINANCING
JULY 1, 1934 – NOV 1, 1936

TYPE FINANCING	P.W.A. OR W.P.A.	NO GOVERNMENT AID	GENERAL OBLIGATION BONDS	SEWERAGE REVENUE BONDS	COMBINATION G.O.B. AND S.R.B.	WATER AND SEWERAGE REVENUE BONDS	SPECIAL ASSESSMENT	GENERAL FUND
NUMBER PROJECTS	44	5	10	21	2	8	3	5

the belief that no real need for the project existed. About 20 projects now under construction, propose to make use of the sewer rental scheme of paying for the betterment and plant operation.

The disposition of the bonds is interesting. Ten municipalities disposed of sewerage revenue bonds on the market, in 12 cases bonds were taken as security for Federal loans and in 1 case (Litchfield), $10,000 worth of bonds were sold privately and the balance were taken by the government. Where bonds were sold privately, it is interesting to note that most of them were purchased by local buyers. Only in one case (the Lincoln project) were the bonds discounted.

Setting up the basis for the sewer service charge is extremely important. The rate schedule should be as uninvolved as possible, first from the point of administering it, and secondly, to eliminate possible opposition to the scheme. A rate schedule from which the average user can himself easily estimate his bill has proven its desirability, especially during the period when the project was being developed.

Three principal methods have been employed in setting up the basis of service, (1) water consumption, (2) connection basis, (3) fixture basis. A detailed discussion of each as applied by the municipalities listed in Table 3 follows:

Water Consumption Basis. Of the 23 sewerage rate schedules, 12 are based upon water consumption. Nine adopted the usual sliding scale for various quantities of water used and 2 (Batavia and Kewanee) applied the scale of sewerage rates to the amount of the gross water bill. Litchfield, the remaining one of the twelve, has adopted a schedule combining a flat service charge of 25 cents per month with a flat water rate of 5 cents per 1,000 gallons used. For large water or sewer users, special contracts are drawn.

A wide variation in the charges made in the lowest and highest quantity brackets of the rate scales is shown. The range of charges is from 6.5 to 35 cents per 1,000 gallons in the lowest bracket and from 2.5 to 20 cents per 1,000 gallons in the highest. The averages are 22.4 and 9.1 cents per 1,000 gallons respectively in the lowest and highest brackets.

The Macomb and Monmouth ordinances provide for unmetered services at flat rates of $4.20 and $3.00 per year, respectively. Libertyville charges $1.50 per capita per year for domestic services where the public water supply is not used but private supplies are utilized. Also all industries employing 6 persons or more are charged a flat $1.00 per employee per year regardless of the water consumption. Princeville also abandons the water consumption basis for schools, industries or other connections serving 20 persons or more. There, a service charge of $10 per year plus $1 per capita per year has been substituted.

At Batavia and Kewanee the respective sewer service charges are 30 per cent and 67 per cent of the gross water bill in the lowest bracket and both are scaled

TABLE 3
FINANCING BY SEWERAGE REVENUE BONDS
JULY 1, 1934 – NOV. 1, 1936

MUNICIPALITY	1930 POPULATION	OWNERSHIP OF WATER WORKS	SEWERAGE REVENUE BONDS						BASIS OF CHARGE	SEWERAGE RENTAL CHARGES							REMARKS
			REFERENDUM HELD	AMOUNT ISSUED $	INT. RATE %	TERM IN YRS.	PURCHASER	PRICE OBTAINED $		PERIOD BILLED	MINIMUM CHARGE (1) AMOUNT $	MINIMUM CHARGE (1) ALLOWED	DISCOUNT OR PENALTY (2)	YEARLY COST TO AVERAGE 1-FAMILY RES.– $ (3)	NUMBER SERVICES	RENTALS COLLECTED %	
Abingdon	2,771	Public	No	36,000	4	25	Gov	Par	Type Connection	Y	2.75	Domestic Conn	None	2.75	525	98	$1,750 per yr public benefit
Batavia	5,045	Public	No	77,000	4	20	Gov	Par	Water Consump.	Q	0.75	3,000 gallons	+10	3.00	1,600	80+	$6,000 per yr public benefit
Belvidere	8,123	Public	Yes	137,500	4½	25	Market	Par	Water Consump.	Q	2.25	7,100 gallons	-10	9.00	1,800	(6)	
Edwardsville	8,235	Private	No	140,000	4	25	Gov	Par	Water Consump.	M	0.75	12,000 gallons	+10	9.00	1,600	90	
Effingham	4,978	Private	No	29,000	4	20	Gov	Par	Fixture	Q	1.50	4 Fixtures	+15	6.60	1,010	(6)	
Gillespie	5,111	Public	No	50,000	4	25	Gov	Par	Type Connection	Q	1.75	Domestic Conn	+10	7.00	800	(6)	
Hillsboro	4,435	Public	No	62,000	4	18	Gov	Par	Water Consump	M	0.50	3,000 gallons	+10	6.00	700	98	
Kankakee	20,020	Private	No	217,500	4	30	Market	Par	Fixture	M	0.50	5 Fixtures	None	6.00		(6)	
Kewanee	17,093	Public	No	120,000	4	20	Market	Par	Water Consump	Q	1.00	4,000 gallons	+5	4.00	1,900	(6)	$3600 per yr public benefit
Ladd	1,318	Public	No	32,000	4	30	Gov	Par	Type Connection	Y	6.00	Sink & Basin Dr	+10	9.00	290	(6)	
Libertyville	3,791	Public	No	45,000	4	20	Market	Par	Water Consump	Q	1.25	3,000 gallons	None	5.00		(6)	
Lincoln	12,855	Private	No	46,500	4	20	Market	42,500	Fixture	M	0.50	5 Fixtures	-10	6.00	2,000	(6)	
Litchfield	6,812	Public	No	60,000	4	30	G.O.B.	Par	Water Consump.	M	0.25	Domestic Conn	+10	4.20	1,213	90+	$10,000 bonds sold locally
Macomb	8,509	Public	Yes	68,000	4	20	Market	Par	Water Consump	M	0.25	2,000 gallons	-25	3.00	1,800	92	
McHenry	1,354	Public	No	20,000	4	20	Gov	Par	Type Connection	M	0.60	Domestic Conn	+10	7.20	400	82	$300 per yr public benefit
McLeansboro	2,102	Public	No	23,000	4	30	Gov	Par	Fixture	M	0.50	4 Fixtures	+5	7.20	200	(6)	$17,000 G.O bonds also issued
Monmouth	8,666	Public	No	122,000	4	25	Market	Par	Water Consump	M	0.55	2,000 gallons	-33⅓	6.60	1,650	98	
Mt Morris	1,902	Public	Yes	23,000	4	15	Market	Par	Water Consump	Q	1.50	11,250 gal	+10	6.00	525	98	
Nashville	2,243	Public	No	44,000	4	25	Gov	Par	Type Connection	M	1.00	Domestic Conn		12.00	(5)	(6)	$12,000 G.O bonds also issued
Polo	1,871	Public	No	28,000	4	20	Gov	Par	Water Consump	Q	2.50	13,000 gallons	+10	10.00	425	96	
Princeville	984	Public	No	34,500	4	25	Gov	Par	Water Consump	Q	2.00	6,000 gallons	+10	8.00	84	100	
Salem	4,420	Public	No	34,000	4	20	Market	Par	Fixture	M	0.50	5 Fixtures	+10	6.00	839	100 (7)	
Waterloo	2,239	Public	No	51,500	4	25	Market	Par	Type Connection	M	1.00	Domestic Conn	-10	12.00	(5)	(6)	

(1) For domestic service only.
(2) Minus sign denotes discount. Plus sign penalty
(3) Estimated with no allowance for discount or penalty
(4) State institution will contribute to operation expense. Amount not yet established
(5) New sewer system under construction. No services as yet
(6) Collections not started or are in such an early stage that data would not be complete.
(7) Rentals paid so far from surplus in city water and light fund

down to 10 per cent of the gross water bill for greenhouses. Both cities charge schools and industries 25 per cent of the gross water bill, while Kewanee charges industries not using the public water supply at a rate of $1 per employee per year.

Connection Basis. Most of the schedules in this class are quite simple, being based on a flat service charge, scaling to the type of property served. Six municipalities use this method.

The classifications of sewer connections most commonly used and the range of charges for various types of connection are given below:

Type Connection	Range of Yearly Charges—$
Domestic	2.75 to 12.00
Commercial	8.00 to 30.00
Industrial	10.00 to 60.00
Schools	8.00 to 120.00
Public Buildings	10.00 to 120.00

These above classifications are more detailed in some ordinances in which hospitals, hotels, churches, filling stations, etc., are listed individually.

The connection basis is superseded by charges based on water consumption at McHenry and Nashville for classified users. The McHenry ordinance provides that breweries and greenhouses pay 10 per cent of the gross water bill and other industries, hotels and schools pay 20 per cent of the gross water bill, with no connection charge. At Nashville base connection rates are supplemented by a flat rate of 10 cents per 1,000 gallons of water used in excess of 2,000 gallons per month.

Fixture Basis. Schedules in this group are based on the number and kind of plumbing fixtures connected at each property. The fixture basis is well adapted to use in municipalities not owning the public water supply and 3 of the 5 cities using the plan are in this position.

The range of charges made for various kinds of fixtures are listed herewith:

Type Fixtures	Range of Monthly Charges
Bathtub	10 to 15 cents
Separate shower	10 to 15 cents
Stool	10 to 15 cents
Lavatory	10 cents
Sink	10 cents
Urinal	10 to 20 cents
Drinking Fountain	10 cents
Basement floor drain	0 to 10 cents
Industrial floor drain	$1.00
Garage wash rack	25 cents to $1.00
Outside drain	10 to 15 cents

The Lincoln and Kankakee ordinances provide for a flat charge of 10 cents per fixture per month. Lincoln has further provided for special contracts to be made with industrial users. Provisions for commercial and industrial users make the Kankakee scheme the most complicated of any covered in Table 3. In this schedule, commercial and "dry" industrial services serving more than 5 persons are charged from 90 cents to $2.40 per person per year. "Wet" industries pay $1.20 per 100,000 gallons of water in excess of 750 gallons per month per employee, in addition to the commercial basis charge. If industrial wastes exceed certain limiting organic matter contents an additional charge is made. This ordinance also varies the fixture charges for office buildings, restaurants, hotels, garages, beauty parlors, public buildings, institutions, etc.

Some municipalities not owning the public water supply have been reluctant to consider financing under the sewerage revenue act because of possible difficulty and expense involved in making collections. It will be noted that Table 3 includes four such municipalities, all of which, with the possible exception of Kankakee, will take care of collections through the office of the city clerk. The fixture basis of rates is used at Effingham, Kankakee and Lincoln. Edwardsville, however, has been able to use the water consumption basis because of cooperation by a cooperative water company. The city is given access to the water consumption records covering the first quarter of each year and the sewerage rates are based upon this consumption for all four quarters.

Corporative Billings and Collections

The column headed "Estimated Yearly Cost to Average 1-Family Residence" is offered for comparison of rates. However, as cautioned previously, the amounts of bonds issued, their terms and the provision for public benefit payments from general funds must be considered when making comparisons. For instance, the low figures shown for Abingdon and Batavia and Kewanee are partially due to the fact that annual public benefit payments of $1,750, $6,000 and $3,600, respectively, are provided for. In all cases, the rates established are expected to be adequate to pay for the operation and maintenance of the sewerage system, to provide a reasonable depreciation fund and pay the principal and interest on the revenue bonds issued.

The relative high figures shown for Nashville, Princeville and Waterloo are due to the fact that in addition to the treatment plant the entire sewer system is new, therefore, making higher initial rates necessary until the number of connections made to the new sewer system will permit them to be lowered. In the other cities the use of the sewerage systems was already established.

To encourage prompt payment of service charges, most of the municipalities listed in Table 3 have included provision either for a bill discount or penalty in the rate ordinance. The maximum penalty shown is 15 per cent (Effingham) and the greatest discount allowed is 33⅓ per cent (Macomb).

In considering the percentage of collections made (Table 3), it should be remembered that all of the municipalities have been making collections for less than 2 years. The figures indicate, however, that the revenues under this law are dependable. Some difficulty has been encountered in making collections from tenants of rented or leased property but when the owner is notified that a lien will be filed against the property, payment is usually forthcoming. Who ultimately pays in cases of this kind must be decided between the owner and tenant. The rate ordinances provide that bills become delinquent in from 30 to 60 days after their rendition. Thereafter such delinquencies are recognized as real estate liens by the law. Some ordinances also provide for shutting off the sewer service where delinquencies exist. It is interesting that in some instances where the water and sewer charges are made on the same bill the sewerage revenue law results in prompter payments and fewer delinquent water bills.

The complete collections shown for Princeville apply to the first quarter for which bills were sent out. At Salem, sewer service bills are stamped "Paid" when mailed, the funds being taken from a surplus now on hand in the water and light fund. This has been done since January 1, 1935, and will be continued indefinitely. This arrangement keeps the user aware of the value of the service he is receiving and also gives him an estimate of what his future bills are likely to be.

The Libertyville project is particularly interesting because the sewerage revenue ordinance applies only to

TABLE 4
FINANCING BY SEWERAGE AND WATER REVENUE BONDS
JULY 1, 1934 – NOV. 1, 1936

MUNICIPALITY	1930 POPULATION	WATER AND SEWERAGE REVENUE BONDS								COMBINED WATER AND SEWERAGE CHARGES						
		REFERENDUM HELD	AMOUNT ISSUED $	ALLOTTED TO WATER $	ALLOTTED TO SEWERAGE $	INT. RATE %	TERM IN YEARS	PURCHASER	PRICE OBTAINED $	BASIS OF CHARGE	PERIOD BILLED	MINIMUM CHARGE (1) AMOUNT $	MINIMUM CHARGE (1) FOR	DISCOUNT OR PENALTY % (2)	YEARLY COST TO AVERAGE 1-FAMILY RES. $ (3)	NUMBER SERVICES
Algonquin	866	No	28,500	None	28,500	4	20	Gov	Par	Flat rate & water	Q	4.50	10,000 gallons	None	18.00	184
Barrington	3,213	No	275,000	34,000	241,000	4½	20	Market	268,125	Type conn & water	Q	5.75	5,000 gallons	+10	23.00	950
DuQuoin	7,593	Yes	360,000	220,000	140,000	4	20	Gov	Par	Type conn & water	M	3.00	4,000 gallons	None	30.00	
Elmhurst	14,055	No	303,000	133,000	230,000	4	20	Market	Par (4)	Type conn & water	M	1.50	2,800 gallons	−5	18.00	
Rochelle	3,785	No	67,500	None	67,500	4½	10	Market	62,000	Water cons.	Q	3.00 (5)	7,500 gallons	(6)	9.00	1,250
Sullivan	2,339	No	190,000	92,000	98,000	4	30	Market	184,300	Type conn & water	M	1.90	1,000 gallons	−10	22.80	375
West Dundee	1,697	Yes	70,000	13,000	57,000	4½	22	Market	Par	Type conn & water	Q	4.50	13,250 gallons	None	18.00	
Wyanet	859	Yes	36,000	None	36,000	4	29	Market	Par	Type conn & water	M	2.25	1,200 gallons	+10	27.00	(7)

(1) For domestic service only.
(2) Minus sign denotes discount. Plus sign penalty.
(3) Estimated with no allowance for discount or penalty.
(4) Small discount because outstanding water bonds had to be recalled. Same applies to Barrington and Sullivan.
(5) Original water rate. Not increased when new bonds issued.
(6) Discount of 1 cent per 100 cubic feet.
(7) New sewer system under construction. No sewer service as yet.

that part of the village within this district. Bills for sewerage charges will only be sent to those living within this district. The city of Collinsville is developing a similar project at this time.

The Libertyville ordinance is unusual in that a service charge of $1.00 per year is made for each vacant lot in the sewer district, the charge being cumulative and payable at the time a connection to the sewer is made. A few of the other municipalities listed in Table 3, among which are Abingdon, McHenry and McLeansboro, have provided for future sewer connection charges of from $5 to $10.

Financing by Combined Water and Sewerage Revenue

Information concerning 8 projects financed under the combined water and sewerage revenue plan is presented in Table 4. This law authorizes combining of the water and sewerage systems into one utility—a logical procedure, since this combination provides for the administration of the complete handling of water from the production and distribution to its collection, treatment and final disposition as waste. One product may be considered "new water" and the other "used water"—the important element in both supply and disposal, however, is that of service rather than the respective values of in-put and out-go.

Referendum approval is provided for in this procedure in the same way as in the sewerage revenue law and Table 4 shows that such elections were petitioned in 3 of the 8 projects. Only one proposed project under this plan was suspended because of an unfavorable referendum.

In combining the water and sewer utilities, the law provides that any outstanding bonds issued for the original water and sewerage systems must be refunded. The fact that previously issued water bonds had to be prematurely called at Barrington, Elmhurst and Sullivan accounts for the small discounts at which these bonds were sold.

Water consumption is the main basis for all the rate schedules in this group but only the schedule used at Rochelle is based on water consumption alone. All others provide for a base (flat) sewer service charge in addition to the water rate scale. This plan has a definite advantage in that charges for public water service alone, public sewer service alone or combined water and sewer service can be readily segregated from the schedule.

The water rate scales average about 17 and 42 cents per 1,000 gallons respectively, in the highest and lowest quantity brackets, the range being from 15 to 62 and 5 to 30 cents per 1,000 gallons in the respective benefits. Only in the Barrington schedule are the water rates classified into domestic, commercial and industrial groups.

Algonquin uses a flat sewer service charge of $10 per year for all sewer connections and the others (excepting Rochelle which has no separate sewer charge) have scaled the sewer charges to more detail, based on the type of property served. The range of sewer charges for various types of connections are listed as follows:

Type Sewer Connection	Range of Yearly Charges—$
Domestic	9 to 15
Commercial	12 to 100
Industrial	36 to 405
Schools	30 to 200
Public Buildings	12 to 24

Minor modifications of the above charges based on fixtures used, population served, amount of water quantity charge, etc., have been made in some of the rate ordinances. For instance, commercial services at Barrington are charged from $1 to $3 per year for various fixtures in addition to a flat commercial charge of $20 per year. Industrial users are charged 5 cents per 1,000 gallons of waste discharged to the sewer in addition to flat charges scaled to the kind of industry.

Hydrant rental charges are provided for in the Sullivan and Wyanet ordinances. At Sullivan this rental is to be sufficient to maintain $5,000 in the water works and sewerage fund but is not to exceed $4,050 per half year. A rental of $2.50 per hydrant per month is called for at Wyanet.

Care is advised again in comparing the estimated annual costs to the average residence to make certain that all the information for each project is considered. Attention is called to the relatively low charge at Rochelle where the original water rates were not raised when the bonds were issued for financing the sewage treatment improvement. Here a surplus was available in the water fund at the time. The hydrant rentals included in the Sullivan and Wyanet ordinances should also be noted. The relatively high charges at Barrington, DuQuoin, Sullivan, West Dundee and Wyanet are mainly due to the extensive nature of the improvements carried out. Also, Sullivan and Wyanet installed new sanitary sewer systems and fewer connections in the early years could be counted upon for revenue.

Data relative to the per cent of collections made are not available at this time. However, it is generally felt that delinquencies under this plan can be discouraged

more easily than under the sewerage revenue law, as the water service can be discontinued much more easily than a sewer service. A delinquency period of 30 days after rendition of the bill is commonly provided for.

Summary

In some projects by necessity, and others by choice, the service charge method of financing of sewerage works is rapidly displacing financing by general obligation or special assessment despite the fact that the service charge laws have been available for less than 2 years. Particularly interesting is the fact that the newer methods have become especially popular among the smaller municipalities, although a number of larger cities are also using them. Besides offering a method whereby the sewerage system is paid for equitably on the basis of service rendered, a community already bonded to the constitutional limit can now obtain needed improvements without resorting to special assessment, which in recent years has generally been unpopular to both municipality and bond buyer.

The flexibility of the application of the act and its adaptations are useful. These bonds can be used to entirely finance the project or can be used to supplement general obligation bonds where the latter can not be used to finance the entire project because of constitutional limitations. After sewerage revenue bonds are issued, advantage can be taken of a surplus in general funds or municipal water and power plant revenues to reduce the charges to users. It should also be noted that where a municipality includes two or more sewer districts the sewerage revenue bond plan can be applied to an improvement serving only a portion of the municipality.

Another important outcome of the new methods of financing should be an improvement in maintenance and operation of sewage treatment works. In the past, operation budgets dependent on general taxes have often been inadequate. Under the revenue laws sufficient operation funds are provided to insure satisfactory service to users and efficient and economical operation. The rate schedules have also been planned to permit a depreciation fund, thus providing a source of money with which to make needed future additions.

No set conclusions can be drawn as to when certain types of rate schedules, or basis for charges, should be adopted. These are primarily to be decided on the basis of local conditions, such as ownership of water supply, type of industries, commercial services, metering of water services, type of water, rate schedule, etc., and all of these should be taken into consideration by municipal officials and engineers in the development of rate schedules.

It is also suggested that rate schedules be kept as uninvolved as possible so as to facilitate administration of the rate ordinance and to eliminate objection to this type of financing during development of the project. Citizens will be less likely to object if they can readily understand the rate basis and probable cost to themselves as users.

The dim and distant future may bring more equitable and perhaps even less "painful" methods of sewerage works financing but basically the service charge laws certainly appear to be a step in the right direction. Though the arrival of this legislation in Illinois is somewhat belated, there are many municipalities still remaining which will find in it the key to the solution of problems involving the collection, treatment and disposal of sewage.

Acknowledgment.—This article, presented as a paper before the Illinois Society of Engineers on January 30, 1937, has been assigned WATER WORKS AND SEWERAGE for publication.

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Flood Pictures of Louisville's Water Works And "The End of the Road"

The above group of pictures show what happened to Louisville's recently renovated pumping station. The high water line of the flood was 5 feet above the elevation of the water when these pictures were taken by Wellington Donaldson. The lower left might be captioned "The End of the Road." It was the pump station road. At its end is the station barely visible. Down the "road" motor-boats carried food, supplies, assistance requested by radio station P1 in the pump house (here shown) calling station P2 on land. The use of code at times was distressing when, for instance, an order for 8-one inch ells brought one eight inch elbow and a length of pipe.

▼

Jim Rumsey Now With Greeley & Hansen

James R. Rumsey, former well known inventive and progressive Superintendent of Sewage Treatment, at Grand Rapids, Mich., and valued contributor to the pages of WATER WORKS AND SEWERAGE, has become associated with Greeley & Hansen, prominent firm of Chicago Engineers.

J. R. Rumsey

In his new position Mr. Rumsey is devoting much of his time to the design and construction of Buffalo's Sewerage and Sewage Treatment Works Project, on which his firm are consultants. He may best be reached through the Chicago offices of Greeley & Hansen, 6 North Michigan Ave.

EXPERIENCES IN WELL CONSTRUCTION*

By J. A. CARR

Superintendent, Water Department, Ridgewood, N. J.

The Author

IN PRESENTING this paper on well construction, let me say that I do not pretend to be an expert in this line. However, based on my own experiences, I shall attempt to bring to your attention a few points from the user's or purchaser's angle which may be of value to some.

My remarks will be confined to the drilling of wells in rock, that being the type of well with which I am most familiar.

The most important points in the construction of a new well seem to be the following:

1. Full and complete specifications and a bid sheet permitting a fair comparison of prices
2. The selection of a responsible contractor
3. A full-size hole, which is kept plumb
4. Proper sealing
5. Proper and complete testing

Specifications and Bid Comparisons

It would seem as if the preparation of specifications for drilling a hole in the ground should be a simple matter. In my opinion it is not as simple as it first appears. There are several points both in the specifications and in the bid sheet which may cause difficulty in deciding on the low bidder and create misunderstanding in making payments. These points should be clearly set forth in fairness to both the contractor and the purchaser.

We, in Ridgewood, do not contract for a flat sum to a fixed depth, but call for bids by the foot. For instance, our bid sheet reads as follows:

Item 1. For drilling, furnishing, setting and sealing, both a ..... inch and a ..... inch casing from the surface of the ground to rock, as specified for $..... per lineal foot.

Item 2. For drilling a ..... inch well from the bottom of the casing to a point 150 feet deep for $..... per lineal foot.

Item 3. For drilling, etc., ... from a point 150 feet deep to a point 250 feet deep for $..... per lineal foot.

Item 4. For drilling, etc., ... from a point 250 feet deep to a point 500 feet deep, etc.

Usually the most expensive portion of the well is that portion which is cased down to and into rock. The depth into rock to which the casing will be carried cannot always be decided in advance. So, in order that all bids may be considered on an equal basis, the following statement is made in the specifications: "For the purpose of comparing bids, the distance from ground surface to rock will be considered to be ..... feet." The distance mentioned is the approximate depth we believe the rock to be.

Our specifications provide that we may stop drilling at any depth. Again, so that bids may be comparable, we state in our specifications: "While the contractor's bid is based upon a maximum depth of 500 feet, it is here distinctly understood that drilling may be stopped by the Engineer at any depth. It is guaranteed, however, that the contractor shall be paid for at least 200 feet of drilled well."

We provide that the well shall be tested once by, and at the expense of, the contractor. Furthermore, that more than one test may be required. In this precautionary specification, any uncertainty in bidding as to additional tests will be removed. The specified amount to be paid to the contractor for such additional tests is set up on an hourly basis.

Selection of Contractor

Next after the receipt of bids is the selection of a "skilled and experienced" contractor. This definition is taken to cover those who are not only responsible financially but, more important, those who know how and have the equipment to do a first class job. And, in addition, the desire to do it.

The improper care and use of drilling tools and improper handling of casings may result in defective wells, thereby causing much immediate or future trouble and expense.

There should be absolute insistence that the contractor's representative on the job, who is usually the rig operator, keep proper records and turn over to the purchaser full and complete information as to what is being done, and what is happening as the work progresses. Samples of drillings at various depths should be preserved.

Unfortunately, there are still some drillers who wish their operations to be considered secret. They should be impressed with the fact that there are two parties, the owner and the contractor, who should know all there is to know about the hole. Full and accurate records are most essential for the proper future maintenance and operation of the well.

What Size Hole?

The hole should be started at that size sufficient to permit as many reductions in diameter as may prove necessary and still have ample diameter for pump installation and to permit future work or alterations.

We recently had occasion to insert a 10-inch casing in a well that had already been reduced from 16 inches to 12 inches. Had the hole been started smaller, it might have been necessary to abandon it. It is poor economy to start drilling with a small hole.

The well should be plumbed and gauged at frequent intervals during drilling, in order that the purchaser may be assured a straight plumb hole of the required size. Watching the cable to see that it hangs in the center of hole is a rough check for plumb. The bits should be frequently checked to see that they are the full diameter required.

*A paper presented before a joint meeting of the New Jersey Section of A. W. W. A.; New Jersey Water Works Ass'n, and South Jersey Association of Water Superintendents.

While a hole slightly out of plumb, so long as it is a straight hole, does not interfere to any great extent with a pump setting, a zigzag or corkscrew hole can cause no end of trouble and expense. This fact was vividly demonstrated to us recently when we inserted a 10-inch inner casing in an old 12-inch well. The casing above rock was out of plumb and there was a constriction in diameter of the rock hole which it became necessary to correct before the 10-inch casing could be entered.

Sealing

I believe that there is only one sure and permanent way of sealing a rock hole to shut off surface or top ground water. That is by double casing, in which the annular space between the two is grouted with neat cement.

On new holes we require the outer casing to be driven to the rock. The drilling is then continued the same size as the outer casing to a depth beyond all soft or broken formation, which is equal to the length of the string of tools. The hole is then filled with sand to a point where the inner casing is to set.

The balance of the hole is then partially filled with neat cement. A cast iron plate is welded over the bottom end of the inner casing and it is lowered and pushed into the cement to the required depth. This gives the inner casing a piston action forcing the cement around the bottom of the casing, and up into annular space between the two casings. The balance of the space is filled with cement slurry to the top. After the mortar has set for several days the cast iron plate is knocked out, the sand bailed out of the hole, and drilling continued into rock.

The purpose of the sand is to permit the string of tools to hand out of the casing when drilling is resumed, and thus avoid jarring and cracking the cement.

When inserting an inner casing in old wells, the hole is bridged at the required depth and the same procedure followed.

In placing the cement in the well considerable care is necessary, because if the cement is put in dry it has a tendency to bridge before reaching the bottom and not entirely fill the annular space. We have found it most satisfactory to mix the cement with water to the consistency of heavy cream and pour it in. Whether or not the space is entirely filled can be roughly checked by computing the volume of slurry required.

If the cement is placed dry, a small pipe carrying air from a compressor should be lowered to the required depth and gradually withdrawn as the hole fills. By this means the bubbling air prevents bridging of the cement.

Testing

Tests should be made with a pump of sufficient capacity to handle more water than is expected, and with the pump deep enough in the hole to secure a maximum draw down. The yield should be measured either by meter or orifice.* We do not favor testing with air.

On all wells we require a 72-hour test of continuous pumping. For the first 60 hours the well is pumped to capacity and a maximum drawn down. Usually after the first twelve or fifteen hours a point is found where the water level does not change and the well is pumped at that level until about the sixtieth hour. The pumping rate is then gradually reduced by degrees, at intervals of about an hour, and the draw down at different rates noted. This method gives a very good record of the capacity of the well at different drawn down levels and its rate of recovery. By this method the proper pump setting can be chosen. It sometimes happens that a well will not yield enough more at, say for example, 125 feet than at 75 feet to make it worth while to pump against the additional head.

In being more positive, we prefer the above method of pumping to capacity first and then slacking off, to that of drawing the well down gradually. If a well recovers to a certain yield and draw down, after having been pumped for 60 hours in excess of that amount, it is reasonably certain that it will maintain that capacity at that draw under ordinary service conditions.

While tests are being carried on hourly, readings for lowered water table are taken on as many neighboring wells as possible (public and private), within a half-mile radius.

In concluding, may I call your attention to the fact that several states are licensing well drillers and have adopted well drilling codes. I understand such a bill is now in committee in our New Jersey legislature. It is known as Senate Bill No. 55 and was drafted by the New Jersey Division of the American Association of Well Drillers. This bill provides for state supervision of all well drilling and the licensing of all well drillers. I have read the bill and believe it to be a decided forward step toward the securing of competent drillers and properly constructed wells. I also believe that the bill merits the support of the membership of this Association, both individually and collectively.

*In the matter of evaluating yields and draw down in well testing the reader is referred to the worthy article—"An Improved Method of Rating Wells," by Paul F. Howard, in the December, 1936, issue of this magazine.—Ed.

And Now It's Doctor Wolman

Abel Wolman
(Doctor of Engineering)

In our last issue we announced that Abel Wolman, retiring Editor of A.W.W.A., had been selected as the John M. Diven Medalist of the Association—the highest award of A.W.W.A. for for services rendered it of an outstanding nature. Now, we learn of another honor (to whom honor is due), which was conferred on its brilliant alumnus by Johns Hopkins University. On February 22, Abel Wolman had conferred upon him the honorary degree Doctor of Engineering, by a proud *alma mater*.

In his philosophical address the same evening before Johns Hopkins University Alumni, Abel Wolman, in discussing "The Engineer and Society" advanced the theme that, "Engineering education might well be required to extend its task beyond the technological to the collateral fields of human relations, economics, and finance. It should assume that responsibility of building those needed men who are quick to apply the knowledge of the time to the needs of the times."

Another engineer, active and valued in the fields of water supply and hydraulics, who received the same recognition and degree along with Doctor Wolman is Professor Franklin Thomas of the California Institute of Technology, and an active Vice President of the Board of Direction of Southern California's Metropolitan Water Commission. Professor Thomas appeared on the program of A.W.W.A.'s 1936 Convention.

SOME LABORATORY KINKS AND TIME SAVERS

By C. AUSTIN HABERMEHL*

Senior Sanitary Chemist,
Bureau of Sewers,
Detroit, Mich.

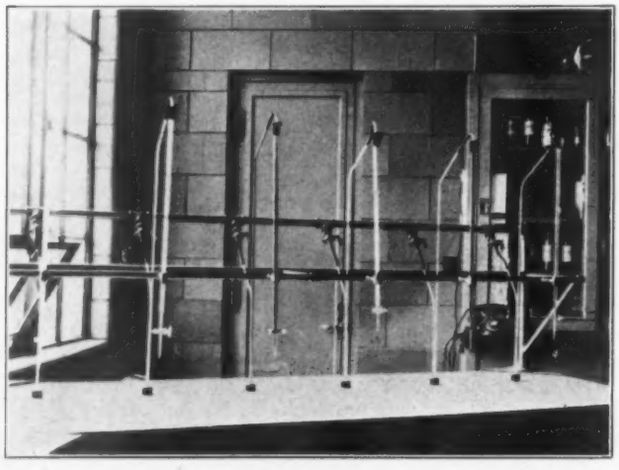
DESPITE the fact that so much interest has been shown in the Dearborn Chemical Sewage Treatment Plant, it has been quite generally overlooked that we have a very well equipped sanitary laboratory. With all the experimental work going on at Dearborn it has been necessary to devise short cuts and time savers for the routine work in order to carry on with the limited personnel we have. It is some of these time savers that I am about to describe in this article.

The Turbidimeter

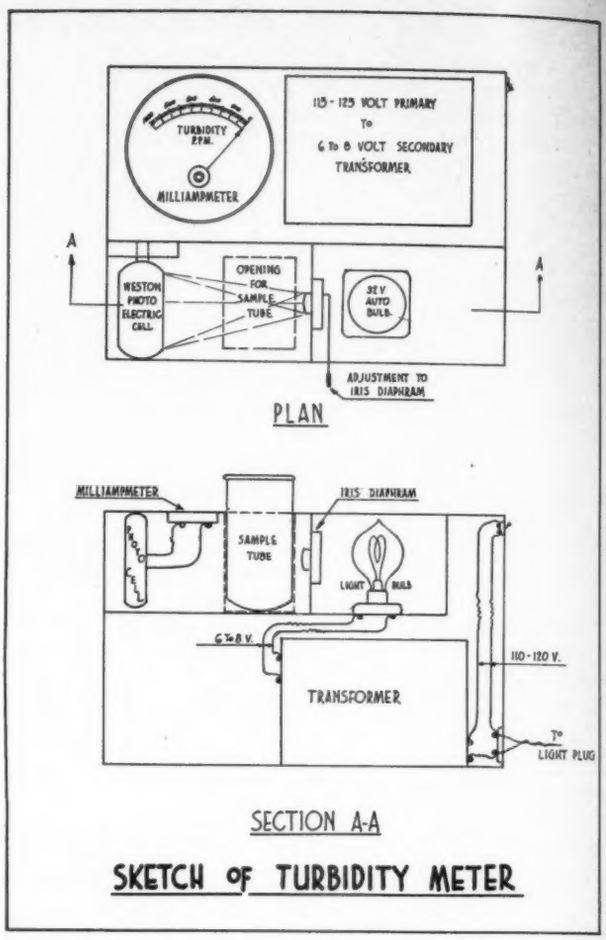
The most important development along these lines was, without doubt, the building and perfection of the Dearborn Turbidimeter. In the winter of 1933 it became necessary to make some investigations involving flocculation, looking forward to installation of plant improvements. It was thought that the measure of residual-turbidity would be as practical a yard stick of mixing and settling characteristics as the more complicated and time consuming suspended-solids determinations. This depended of course on devising some method less complicated and more reliable than the then existing methods for measuring turbidity.

With the idea that a photo-electric cell might be used in that capacity, a Weston photo-cell and a milleampmeter were purchased. With these essential parts a

*At the time this article was prepared the author was chief chemist, Division of Sewage Treatment, at Dearborn, Mich.



Central Titration Table. All Solutions Air-Forced to Burettes from Below; Automatic Zero Settings by Suck Back.



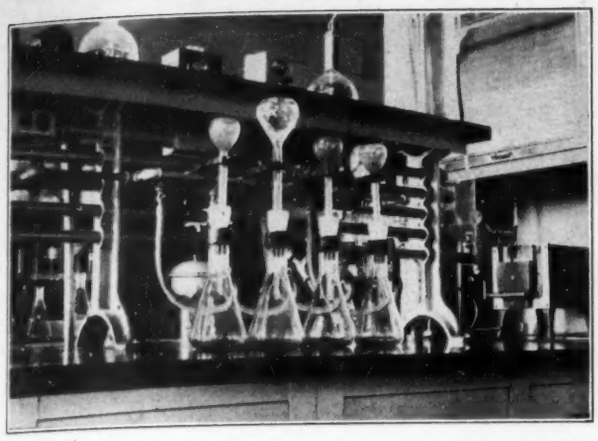
Sketch of Turbidity Meter Developed at Dearborn and Effectively Used in Control of Chemical Dosages.

Turbidimeter was constructed by Mr. Miller, then engineer in charge of the Division, and the writer. Parts from the radio junk box supplied the balance of the necessary equipment.

The unit is housed in the case taken from an old radio battery charger. It is 6 x 7 x 9 inches in size and has quite a finished appearance with the original crackel finish on the box. The meter is mounted with the dial flush with the top of the case adjacent to the hole for the sample jar. As can be seen from the sketch the original dial has been replaced with one that reads directly in parts per million of turbidity. A 32 c.p. auto head lamp bulb is utilized as the light source. This is enclosed in a light tight box with a hole in the side towards the photo cell. In the hole is mounted a complete shutter mechanism (the lens removed of course) taken from a discarded camera. A fine rod is soldered to the lever actuating the movement of the iris diaphragm and passed through to the outside of the box for control of the light intensity. The center line of the light, the shutter opening and the photo cell line up both vertically and horizontally.

Its Use

In practice a jar, similar to the one holding the sample to be tested, is filled with distilled water and placed in the sample opening. The iris diaphragm is then adjusted until the pointer on the meter dial corresponds with zero turbidity. The sample is then placed in the opening and the turbidity is directly read in p.p.m. The zero setting is then again checked with the distilled water to see that line voltage has not fluctuated enough



Suspended Solids Filtration Automatic with This Self-Feed Arrangement.

to change the light intensity since the setting of the zero point was made.

The unit was calibrated by making up standards from Fullers earth as directed in the Standard Methods of Water Analysis. A number of curves were secured, using these standards, by adjusting the distance between the shutter opening and the photo cell. One best setting was finally decided on and the dial calibrated to produce direct readings in steps of 2 p.p.m. could be made from 0 to 50 p.p.m.; and to 5 p.p.m. from 50 to 100 p.p.m. of turbidity. The scale goes up to 1000 p.p.m. with greater interpolation necessary as the range increases. It was possible to secure a curve where 0 to 50 p.p.m. occupied the full scale of the dial and where turbidities of 1 p.p.m. might be easily read. This method would therefore seem to have a possible application in the field of water treatment. It is decidedly simple and convenient, with accuracy of results exceeding that of the human eye.

Some 5000 different turbidity readings were made during the period of making the flocculator tests. Results showed that we were justified in using turbidity rather than the more cumbersome suspended solids tests as a basis for correlating chemical dosage, flocculating time, efficiency and economies.

It is still not known what effect dissolved color might have on the accuracy of turbidity readings with the machine. We fortunately are not troubled with color in our sewage. Some few experiments have been made in measuring color intensities. From those it seems altogether possible that the unit might be utilized to measure color in non-turbid solutions. This brings up the question of the possible use for the "electric-eye" in determinations of pH, Iron, C12, Nitrogen, etc. It is hoped that we may have more time in the future to investigate some of these angles.

Improved Titration Facilities

As can be seen in one of the pictures, our titration table is equipped with six burettes. From left to right they contain N/50 H_2SO_4, Potassium Oxalate, Potassium Permanganate, Sodium Thiosulfate, Silver Nitrate and N/10 H_2SO_4. The back rack also serves as an air pressure line which is connected to the solution supply bottles, located in the cabinet beneath the table top, through a two-way valve. There is also a line from the supply bottles discharging into the tops of the burettes through a specially bent drawn jet tube, with the tip set at the elevation of the zero line of the burette. In practice the burette is filled by opening the valve and putting air pressure on the supply bottle. This forces the liquid up the supply line and into the top of the burette. When the level of the liquid has reached a point slightly above the zero line the two-way valve is closed in the pressure line. This automatically vents the supply line, and so causes a syphon that will pull the solution level down to the zero point in the burette. Regarding this there is nothing new except the ease, quickness and accuracy of burette filling, to the definite zero point, for each new operation. This is more than a handy arrangement when a number of routine samples have to be titrated because numerous subtraction of readings, with likely errors, are eliminated.

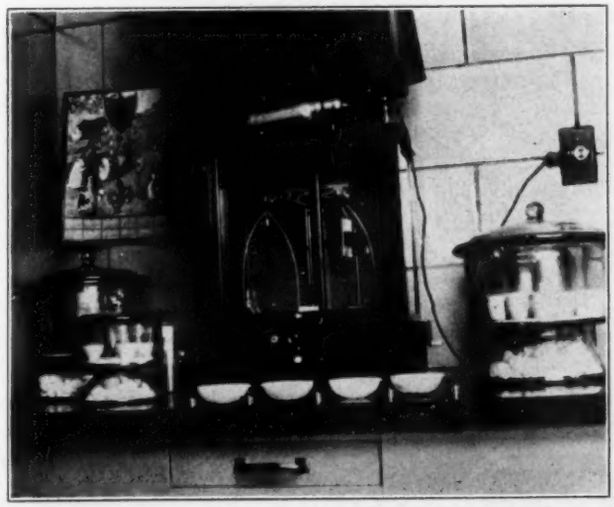
Automatic Suspended-Solids Filtration

Every one engaged in sewage analyses has felt the exasperation that comes with a suspended-solids determination when the sample will not filter well. We have overcome this nuisance to a large extent by making the filtration of these samples almost an automatic function. A glance at the picture will show the arrangement without much description being necessary. As we run the suspended solids determination on the raw sewage and effluent from both plants, as a matter of routine, our rack is composed of four clamps with the necessary hose connections to the valves on the vacuum line. Under different conditions almost any number of suspended solids samples can be filtered at the same time and still require no attention except to shut off the vacuum line when the filtration is completed. We have found that the velocity of travel of the air bubbles rising in the volumetric flask, while filtering, gives sufficient agitation to keep the solids in suspension and prevent them from adhering to the sides of the flask.

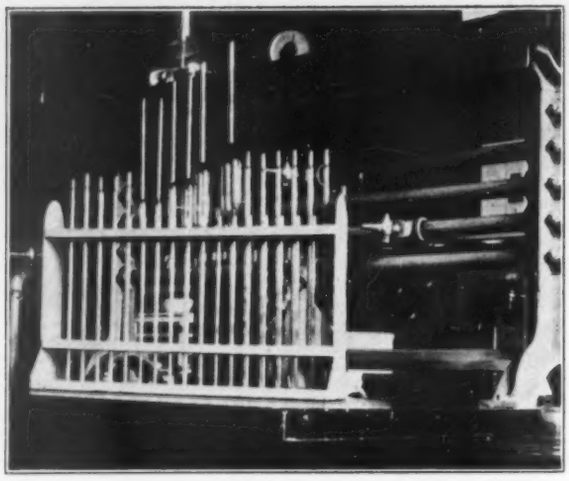
Wooden test tube clamps similar to the spring type clothes pin are used to hold the volumetric sample flasks. Suction flasks of 500 ml. capacity are used so any volume from 25 to 500 ml. may be conveniently filtered without loss of any of the filtrate.

Solids Weighing

One of the most tedious jobs in the busy laboratory is the accurate weighing of routine solids samples. At Dearborn, we determine suspended and total solids on the raw sewage and effluent from both plants, as well as the volatile of each, 365 days of the year. This makes for a considerable number of weighings. To facilitate these weighings silica "Vitreosil" evaporating dishes are used in the total solids determination. We find that these dishes will not vary in weight more than two to three-tenths of a milligram from one determina-



Weighing Tables.—Chainomatic Balance. Note Balance Drop-Cover Suspended Above. Light Weight "Vitreosil" Solids Dishes, with Home-Made Tare Weights Shown Between.



All Metal Pipette Rack—Rugged, Non-Rattle, Secure.

tion to another. Counter weights were made up for these dishes, using the brass tops from some discarded cartridge type fuses. The brass tops were cut off and bottoms soldered in. The tops were then drilled and tapped and a short brass rod was threaded in, so they might easily be picked up with the tweezers. They were then loaded with fine shot, to balance the dish, through the hole made by unscrewing the handle. They were then burnished, numbered and given a coat of clear lacquer so they look just as finished as the original balance weights. We have two complete sets of five each of these dishes and weights so they may be used on alternating days. With our "Chainomatic" balance it is not necessary to use any further weights when using these dish counter weights. Operating the chain completes the weighing. This easily cuts down weighing time at least two-thirds on this particular analysis. The accompanying picture gives some idea of the size and appearance of these weights (not too clearly visible) between the "Vitreosil" dishes in front of the balance. There is one other piece of equipment on our balance that we can not praise too highly. If one is not familiar with the effect of a magnetic damper on a sensitive balance it is hard to adequately describe its usefulness. It will, without any exaggeration, speed weighing time at least fifty per cent and is well worth the ten dollars charged for it as extra accessory.

The balance is kept covered at all times when not in use. The cover is of rubberized cloth. A light frame was built into the top of the cover in the shape of the balance. A pipe frame is attached to the balance table, directly in the rear of the balance, that runs up and over the unit. A cord with a counter weight runs through this piping and is attached to the cover. In the picture the cover is seen, raised to just clear the balance. The ease of pulling a cord means greater balance protection at practically no effort or loss of time.

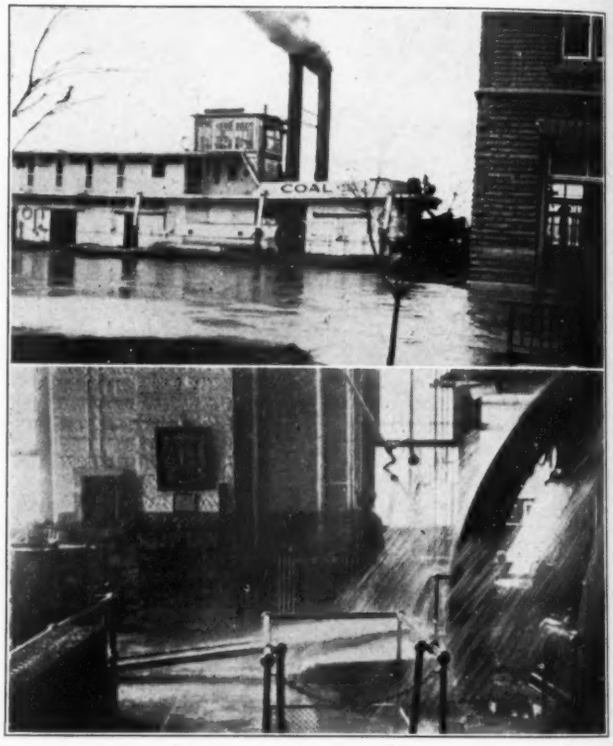
Pipette Rack

A pipette rack constructed at Dearborn is also pictured here. It is in the conventional shape, but is made of sheet metal and, so, is more rigid than the usual wooden ones. As may be seen it holds two rows of pipettes. In the front row are kept the various types of the one ml. size in use. The back row contains all sizes from 5 to 500 ml. The novelty is the way the holes are drilled and spaced, so that each size is held firmly and is always in its proper place.

Louisville's Answer to Old Man River

The accompanying pictures taken by Wellington Donaldson constitute a page of romance, and not-to-be-forgotten history in emergency water supply engineering.

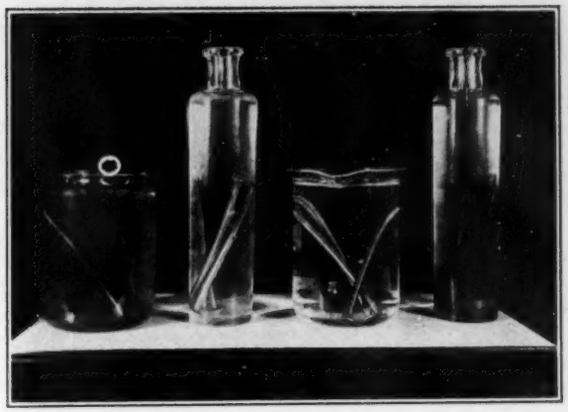
Elsewhere in this issue are pictures showing the depth to which the Ohio River flooded out Louisville's pumping station. How to keep water in the mains of distressed and distracted Louisville was a problem of no mean dimensions or import. The answer was flung at Old Man River by L. S. Vance, Chief Engineer and Superintendent of Louisville's Water Department. If the river brought disaster it should be made to bring aid. He therefore arranged to have this Ohio River sternwheeler tied up to the pump house, along with a barge of coal. In three hours expert oxy-acetylene welders had steam lines run from the packet's boilers into the station and connected to one of the half submerged 24 m.g.d. triple expansion pumping units.



The upper picture shows the steam packet tied up to the station with boilers being forced to their safe limits 1440 minutes every day. The lower view was gotten inside the station when the main bearings of the pump were yet submerged. Note the fly wheel throwing water. When the river went down how the packet was gotten off of dry land is not known. But, the health, safety and very life of a major city was at stake and what mattered the possible loss or partial loss of just one more river boat.

With the aid of radio (U. S. Army manned stations) communication was maintained with the mainland—the dry land, rather—and supplies, aid and food came out to the marooned station on volunteered launches, across tree tops and telephone lines which frequently and hazardously fouled propellers.

This is the story in part told by Wellington Donaldson before the New Jersey Section of A.W.W.A. in an illustrated talk—both interesting and tragic. Mr. Donaldson, with Commissioner Binger, Chief Engr. Gould and Chemist Carpenter of the New York Department of Sanitation, went out to Louisville to "do their bit" in whatever direction they could.



Some Rule of Thumb but Very Helpful Observations on the Effect of Treatment on Cold Water Corrosion Control.

SOME COMMENTS ON CORROSION IN WATER WORKS PRACTICE

By CARL N. ALEXANDER

Supt. of Filtration,
Tubize Chatillon Co., Rome, Ga.

The Author

CAUSES of corrosion which water works operators have to deal with are both external and internal. The internal causes of corrosion may be the following:

1. Mineral acidity of water.
2. Dissolved oxygen.
3. Carbon dioxide.
4. Presence of soluble salts.
5. Galvanic effects.
6. Presence of certain micro-organisms.

External causes of corrosion may be:

1. Atmospheric corrosion.
2. Soil corrosion.
3. Accidental infiltration of corrosive liquids or marsh water corrosion.

Internal Corrosion

Acidity of the Water

Mineral acidity in natural waters is rare. However, it can be observed in spring and well water located close to pyrite mines. The iron sulfide oxidizes, yielding iron sulfate which gives the water a peculiar acid taste. Streams impregnated with mine waste frequently contain free mineral acid.

Correcting such acidity is easy to do. A small addition of lime, for example, serves to get rid of both the acidity and the iron, but leaves in the water the objectionable calcium sulphate.

Dissolved Oxygen

The important factor in iron corrosion under neutral aqueous conditions is the supply of dissolved oxygen.

The presence of a deposited film is a very valuable factor in preventing or retarding corrosion. Unfortunately, it takes some time to form such films. For instance, when we started operating our plant, despite the correction of the water to a pH of 8.5, we had red water for about 1½ months.

In many conditions, an extra addition of lime, so as to have enough calcium bi-carbonate present in the water will accelerate the formation of such film in the water mains. However, an excess of calcium bi-carbonate is to be carefully watched. The volume of incrustation can be such that it decreases rapidly the rate of flow of water through the system.

Carbon Dioxide

Carbon dioxide, dissolved in distilled water has a decided acid reaction, and therefore, free carbon dioxide gives a water low pH values. Consequently, the "aggressiveness" of carbon dioxide in any type of water is regulated by the bicarbonate alkalinity and by the acidity of said water.

Free carbon dioxide dissolves calcium carbonate, forming calcium bicarbonate, with a corresponding increase of the pH value, and this chemical reaction can be used to determine whether or not a water will corrode a pipe or yield a protective coating.

A very simple test consists of dividing the water to be analyzed into two parts, then to determine the total alkalinity (methyl orange) and the pH value of the first part. Saturate the second part with powdered calcium carbonate and determine the alkalinity and pH of the resulting water after a thorough filtration through washed filter paper. If the alkalinity and pH of the second test are higher than the first, the water is corrosive. No protective film could form on the inside of the pipes.

If alkalinity and pH are the same for both tests, the water is not corrosive. If the alkalinity and pH of the second sample is lower than the first, the water will precipitate calcium carbonate in the pipe lines.

When a water presents very little or no aggressiveness, one of the easiest ways of minimizing the corrosion is to decrease the hydrogen ion concentration of the water; in other words, to add to it a sufficient amount of lime, sodium carbonate or caustic soda so as to be always in the alkaline zone.

At the Tubize Chatillon Filter Plant, we have continuously corrected the water after filtration by adding

enough sodium carbonate to raise the pH from 6.5 to 7.8 or 8.0. This procedure has proven quite successful in the long run.

Protective Films

As said above, protective film retards corrosion. As a matter of fact, this protection depends upon the nature of the film, which determines the rate at which oxygen might diffuse through it.

The nature of the film deposited after a certain lapse of time inside a water pipe, obviously, depends upon the nature of the water going through it. A chemical treatment which will bring the calcium carbonate close to the solubility equilibrium favors the production of a calcium carbonate coating, especially if the pH is maintained on the high side, as said before.

A film of colloidal, or impervious nature will be better than a film of sandy nature. An impermeable insulating coating is desirable because it not only retards the corrosion, but also prevents "pitting."

Waters of low hardness (15 to 40 ppm), but rich in soluble silicates, are excellent film generators. Our personal experience is that a water should contain at least 50-60 ppm soluble silicates, calculated as silica, to form a protective film. For this reason, at our plant, we are adding 25 ppm silicate of soda (Na_2SiO_3) in order to bring the water of the Oostanaula River from 22-28 ppm to 47.53 ppm in silica content.

Silicates are not the only materials favoring the formation of protective films. Friend, in "Transactions of the American Electro Chemical Society, of 1924," has shown that organic substances reduce the corrosion of iron also, but of course this is purely of academic value.

Presence of Soluble Salts

Salts, in solution, act either to retard or increase corrosion, depending upon their nature, concentration, and other factors. Available information is somewhat contradictory, because a mixture of salts does not generally act like each taken alone.

As a rule, soluble salts such as common salt or sodium sulfate or magnesium chloride, which are found in sea water, are excellent electrolytes and increase rapidly the corrosion of iron when found in a very dilute form. Their protective effect in cold solutions starts only when their concentrations are greater than the one corresponding to a normality of 0.25, which is seldom found in water works practice.

In hot conditions the question becomes worse due to the dissociation phenomena taking place, in which we are not interested for the present.

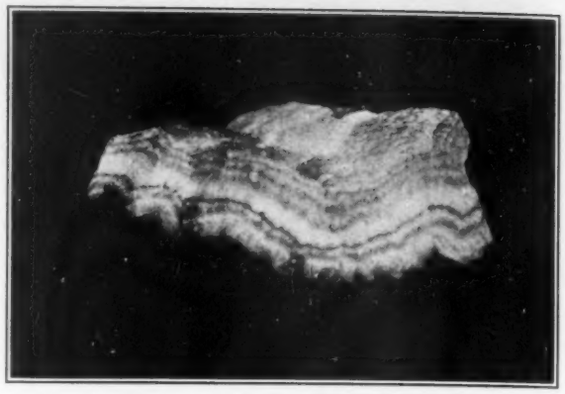
Galvanic Action

As you know, iron in contact with other metals or materials forms an electric cell. An electrical circuit is completed, permitting one metal to become anodic and to enter the water, while the other metal becomes cathodic and becomes plated with hydrogen.

Corrosion occurring due to such effect is generally called "galvanic action." The electric current does not cause the corrosion but it is the corrosion which causes the current. Which metals will go into solution? This depends on the nature of the metal in contact with iron.

If iron is in contact with a more anodic metal, such as zinc, it is the zinc which enters in solution and the iron which is protected, and that explains to you why zinc is used for making galvanized pipe. Also, why it frequently leaves the iron surface.

If iron is in contact with a less anodic metal, it is the iron which enters into solution, and becomes pitted. Here is a table which is very useful to find out what might happen.



What Happens When Soda Ash and Silicate Are Added. This Heavy Deposition Just Beyond Treatment Point on the Pipe Walls Rapidly Thins Out to 1/16 in. Thickness in the System.

	Electrode Potential
Aluminum	+1.700
Zinc	0.7618
Iron (Ferrous)	0.441
Cadmium	0.401
Nickel	0.231
Tin	0.136
Lead	0.122
Hydrogen	0.000
Copper	—0.344
Silver	—0.798

This table gives the electromotive forces of elements. Every metal above iron will dissolve before the iron will. Every metal under iron will cause the pitting of iron. You have all noticed at what rapidity a tin can left in the woods after a picnic rusts. This is because tin is listed after iron. Tin protects iron only as long as the surface of the can is free from scratches. As soon as the surface is damaged, corrosion takes place more rapidly than if the tin were not here.

The greater the difference between the potentials given above the greater the corrosion rate. You also know that when iron is immersed in a copper sulfate solution, copper is deposited on iron. As copper is below iron in the above table, a strong corrosion takes place.

Metals are not the only elements capable of causing "galvanic action." "Milk Scales" or magnetic oxide of iron when scratched constitutes also a dissimilarity of contact, and therefore gives rise to localized corrosion. Iron pipes from different manufacturers showing difference in chemical composition might also cause corrosion trouble when assembled.

The electrical conductivity (salt content) of water is a very important factor, affecting the corrosion. As the conductivity increases the tendency of an iron pipe to pit (when in contact with a substance of dissimilar nature) is much greater. Excessive amounts of sodium chloride, sodium sulfate, etc., are therefore undesirable.

Presence of Micro-Organisms

Some peculiar micro-organisms are found in many natural waters of which Crenothrix is typical, and are responsible for corrosion troubles. The organism does not attack the iron, but assimilates the iron of the internal protective coating of the pipe, and subsequently eliminates it as ferrous oxide, which later is oxidized to ferric oxide by the dissolved oxygen in the water. This ferric oxide is then carried through the system by the bodies of the bacteria or is deposited as nodules or tubercles.

Often the result is the clogging of water pipes which in some instances has been a real calamity. I have been told by our chief chemist, Dr. Barthelemy, that our sister Italian company of Vercelli, Italy, had been facing the necessity of closing down the entire plant in order to clean the water system of iron algea. This was accomplished by a heavy dose of chlorine, followed by flushing out the lines.

External Corrosion

Atmospheric Corrosion

You all know iron pipes exposed to atmospheric conditions corrode very rapidly. They are generally protected by tar paint or by a red lead oxide coating, followed by the application of a second coat of oil paint.

Soil Corrosion

What has been said above regarding internal corrosion is also true of external corrosion. As a rule, underground pipes are made of cast iron, which is considerably more resistant to corrosion than steel or iron. Nevertheless, when corrosion does occur, serious damage may result unless adequate protective means are adopted.

On steel or iron pipe, a good plate of zinc, applied by the hot-dip process is generally efficient in slightly corrosive soils; however, a coating which generally never fails is a bituminous dip coating.

This coating includes refined coal tar pitch, which always contains a certain quantity of very powerful corrosion inhibitors of the same nature as the one generally in use for making metal pickling solutions.

Some coatings include natural asphalt, artificial asphalt, and blown asphalt manufactured from certain kinds of residuum oil. The coating applied in the field is the best because it does not involve any limitation as to fluidity of the coating versus climatic conditions, but it should be supervised very closely.

A preliminary or priming coating is very essential because it constitutes a good binder between the metal and the bituminus coating. A priming coat consists essentially of coal tar or asphalt dissolved in a volatile solvent.

When the soil conditions are particularly bad (infiltration of sea water, acid infiltration from chemical plants, etc.) it has been found advantageous to reinforce bituminous coatings so as to improve their resistance to corrosion. This is generally done by wrapping the pipe with a spiral of paper or coarse grade of cotton fabric saturated with a waterproofing bituminous mixture.

Portland cement coatings have also been recommended in some locations, where conditions are very severe, as in marshy places. Owing to the inhibitive characteristic of hydraulic cements pitting is arrested. Sometimes bituminous coatings are combined with cement coating. After all, the choice of the coating depends upon the following:

1. Expected service of the pipe line
2. Importance of the line.
3. Nature of the pipe
4. Cost of piping system
5. Cost of maintenance.
6. Cost of coating
7. Local soil conditions.

In our plant we are using cast iron pipes containing about 2 per cent silicon. They are coated at the factory with a coal tar pitch by dipping the hot casting in a vat of the bitumen. They are assembled with hemp, or oakum, twisted yarn and lead joints. This type of line gives excellent service in red clay soil of the nature and consistency found around Rome, Ga.

Acknowledgment.—The above paper was presented before the 5th Annual Short School of the Georgia Water and Sewage Works Operators Assn.

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Three Sewage Schools For New York State

Sponsored by the New York State Sewage Works' Association, the Mayor's Conference and the State Department of Health, three Short Schools for Sewage Works Operators are to be held in April at

New York University, April 1, 2 and 3.
Cornell University, April 7, 8 and 9.
Rensselaer Poly. Inst., April 14, 15, and 16.

The program of the school, to be held at New York University, covers the following topics among others: "The Why of Sewage Treatment" (Dean Saville); "Composition and Behavior of Sewages" (Dr. Setter); "Principles of Sedimentation" (Prof. Carpenter); "Primary Treatment" (C. C. Agar); "Digestion and Disposal of Solids" (A. S. Bedell); "Hazards of Sewers and Treatment Works" (J. L. Barron); "Stream Pollution" (F. W. Gilcreas); "Responsibility of Sewerage Operators" (M. Cohn); "Regulation of Sewer Connections and Maintenance" (E. Firth); "Round Table on Operating Problems" (W. Donaldson, Leader).

Deputy Commissioner of Sanitation W. D. Binger will be the dinner speaker. Not having received the programs for the Cornell and Rensselaer Schools topics scheduled for these can not be listed.

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John Chambers Dies

John Chambers, Chief Engineer and Superintendent of the Louisville (municipally owned and operated) Water Company, died January 20. He had been a victim of the dread diabetes and spent the closing 90 days of his life in the hospital. Not many of his acquaintances realized that John Chambers was in his 72nd year. He died a bachelor.

A native of Louisville, he was a graduate of Rennselaer Polytechnic Institute, established himself in private practice as a counsulting engineer, became City Engineer of Louisville in 1908. He resigned in 1921 to become Chief Engineer of the Louisville Water Company—then privately owned. The same year he became a member of the American Water Works Association* which he served in several capacities, and became a member of its governing Board of Trustees in 1929. He was also a member of the American Society of Civil Engineers.

Succeeding Mr. Chambers is L. S. Vance, former Principal Assistant Engineer of the Louisville Water Works and, for some time past, all that the title indicates.

*Louisville Water Company has maintained a Corporate Membership in A. W. W. A., since April 1909 and W. H. Lovejoy, Supt. of Filtration maintains a membership which has run continuously since June 1908.—Ed.

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New York State's Sewerage Construction Keeps Apace

In January the New York State Department of Health approved 26 sets of plans for new construction or sewage works betterments. In this group 21 were municipal plants and five were for private or semi-public projects.

N.E.W.W.A. FEATURES CHLORINATION TOPICS

A Report of the February Meeting

By HARRY A. FABER*
Associate Editor

MEETING in Boston at the Hotel New England, February 18th, members of the New England Water Work Association heard three technical papers on various phases of water and water main chlorination. Also, a new feature, for members primarily interested in the operation of water treatment plants, was introduced. The inaugural staging of a "Chemists' Round Table" simultaneously with the long established "Superintendents' Round Table" was an innovation denoting the growth of interest in water treatment in the New England States.

Chase Tells of Flood Conditions

During the luncheon meeting, E. Sherman Chase, (Metcalf and Eddy, Engrs.) graphically pictured the Ohio flood area conditions. He had just returned from detail in the affected sections, and impressively "brought the flood to Boston." If Boston were in a condition similar to Louisville, all of the city with the exception of Beacon Hill would be submerged, he said. The flow of the Charles River would then carry 65,000 million gallons per hour past the city.

A difficult sanitation problem had been created due to the spoilage of food products—some 600 tons of condemned material being disposed of in an abandoned quarry, and much more in the river. It had been necessary to dispose of 14,000 dead animals—drowned or starved. He complimented the health organizations which worked efficiently under severe conditions.

Chemists' Round Table

(Chairman, Prof. Melville C. Whipple.)

Judging by the enthusiastic discussion of those members attending the Chemists' Round Table session, this feature should become a regular addition to the program.

Topic 1. "What amount of residual chlorine can you maintain in tap water without causing complaints from consumers? Is this amount necessary for satisfactory disinfection?"

For Cambridge, Mr. Smith reported that a dose of 2.2 lb. per m.g. of chlorine produced a residual of 0.08 to 0.10 p.p.m at the plant. This dose gave a residual of about 0.01 p.p.m. in the downtown area. Disinfection had been satisfactory with such residuals and no taste or odor complaints are received. At Newton, Mr. Crocker reported the well water to be of a type very sensitive to chlorine and that it is impossible to maintain an appreciable residual without taste complaints.

Where chloramine disinfection is practiced at Salem-Beverly, Mr. Johnson reported that a 1 to 2 ratio of ammonia to chlorine is used. This was first applied to give a residual of 0.3 p.p.m. at the plant and of 0.13 p.p.m. in the downtown area. It had since been found that maintaining half this residual as the water leaves the plant leaves at least 0.01 p.p.m. at the end of the line. Not only had this given adequate disinfection, but treatment with a persistent chloramine residual had eliminated "slime" from the mains.

It was in the end conceded that no universal rule could be laid down as to the most desirable residual; that such had to be determined for the individual supply; that chloramine disinfection, as a rule, had produced fewer taste and odor complaints and proved a benefit in maintaining a more sterile distribution system.

Topic 2. "What procedure do you find gives satisfactory results in the control of reservoirs for algae?"

It appeared in this discussion that New England has more than its share of taste troubles to deal with. M. S. Wellington of New Haven, finds it necessary to treat all reservoirs with copper sulphate when water temperature reaches 55 to 60 degrees F. Counts of organisms are made on weekly samples, and when counts continue to increase over two sampling periods, immediate treatment is indicated. About 2 lb. of copper sulphate per million proved adequate treatment of the upper 15 ft. of reservoirs and maintained satisfactory taste conditions.

At Hartford, Mr. Gentner had found taste and odor conditions cause less difficulty than had the effects of algae growth on plant operating efficiency. Proven most satisfactory had been treatment of reservoirs with 2 to 2.5 lb. of copper sulphate per m.g. and temporarily stopping use from the reservoir. An old filter plant (West Hartford) is kept in reserve and is used until a better water may be drawn from the usual supply.

Mr. Bean described a difficult condition at the Scituate plant (Providence) in which counts of 60,000 organisms per cc.—largely anabaena—were encountered. Entire surface of the reservoirs had become blue-green in color. By drawing water from an intake level near the bottom, where counts were only about 300 per cc. no trouble was encountered. The condition persisted some ten days and then disappeared without treatment.

When a bottom source had been tried at Wanaque, N. J., Mr. Griffin (Wallace and Tiernan Co.) said the reservoir shortly after construction had shown CO_2 and H_2S (8 to 9 p.p.m.) present up to within 40 ft. of the surface. When microorganisms, usually asterionella, were present they existed to about 30 ft. below the surface. Attempts to draw between these levels had not been entirely successful since a cone apparently was created, drawing first H_2S and then algal tastes into the supply. As the reservoir aged, the amounts of H_2S and CO_2 decreased and less trouble was experienced.

Topic 3. "What do you consider worthwhile tests to be made in connection with plant operation?"

On this, only qualifying answers based on the type and complexity of the plant, were possible. But, in addition to the usual chemical and bacteriological tests, Mr. Johnson said that at Salem-Beverly confirmatory tests for the coli-aerogenes group had been considered unnecessary on raw water known to be polluted, but con-

*Assistant Engr., The Chlorine Institute, New York City.

sidered important tests on the final effluent to show dependable purification. At Leominster, pH is a very important test, since proper coagulation depends upon this characteristic. Coagulation at pH 5.5 produced a good floc and effective color removal. At too high an alkalinity (pH) color would redissolve. There seemed to be indications of residual alum in the filtered water at the same time.

Mr. Bean said that the residual alum test, as a measure of process efficiency, was too often neglected; that the amount passing filters in winter was ordinarily greater than in summer. The complaint of hard water is in general caused by an observable soap scum, and the presence of aluminum and appreciable organic content would add greatly to this undesirable quality. At the Scituate plant a change from 15 p.p.m. hardness with alum coagulation to between 30 and 50 p.p.m. hardness with the change to lime and chlorinated-copper as treatment had been noticed only by laundries concerned with soap consumption. Ferric chloride coagulation and pH correction with lime was now proving an economical and efficient treatment at Providence.

Superintendents' Round Table

(Chairman: H. T. Gidley)

A variety of difficulties, and a smaller number of solutions, was brought forth by the question:

"How do you treat dead ends and overcome water hammer on same?"

The neat answer, that the only way to eliminate such trouble was to eliminate the dead ends, appeared not so feasible as it sounded. Mr. Gidley told of a bad water hammer produced by pumping to a standpipe intermittently with a large capacity pump. A smaller pump, to run continuously 24 hours a day, had been of material aid—and reducing the size of the dead-end main beyond the last hydrant was further beneficial.

Mr. Brigham (Marlboro), described a 7,000 ft. line which could not be tied into the system. Taste conditions were bad in warm weather, but continuous bleeding with a small pipe or hose on hydrants proved very helpful. Objectionable fixture vibration was often caused by improperly suspended plumbing inside the house. He had corrected a serious water hammer on a 6 inch line, carried over a steep hill some 4 miles from a reservoir, by using an air chamber. A pit was dug and large steel pipe used as the expansion tank. In Grafton, the substitution of a triplex for a duplex pump had lessened water hammer, and when this was later changed to a centrifugal pump no further trouble was experienced.

Roger Esty (Danvers), cited a similar improvement by his substitution of a centrifugal pump. In another instance, a manufacturing plant had found leaky valves and closed its gate valves at night to prevent water loss. Then each morning a sudden heavy draft was caused by opening a 6 inch line almost instantaneously. In a laundry the sudden opening and closing of quick-acting valves had proven equally objectionable; was corrected by installation of proper valves. Mr. Gidley said that on automatic gas water heaters, hammer may be eliminated by the installation of an inexpensive pressure regulating valve.

Topic 2. "How are meter readings obtained where houses are locked? Do meter readers note leaks and notify consumers?"

Answers to this question disclosed some original methods that have worked in particular municipalities. Mr. Gidley noted that out of 2300 meters about 300 usually cannot be read. Mailing a card marked so that the owner can mark meter readings and return the information had given only a small percentage of returns. But, when such a card is left by the meter reader at the time of his call, about 190 of the 300 bring returns.

At Winchester, if the regular reader is unable to make the reading, a card is immediately turned in and the case given to a special reader who cares for such cases. A note may be left requesting the owner to telephone and make an appointment for a time at which the meter may be read, and often evening or Saturday afternoon calls are successful. If, in posting the reading consumption is found to be unusually large an inspection for leaks ensues and the customer is promptly notified. If leaks were not known, to the consumer, an adjustment of 40 to 50 per cent of the over-charge was frequently made.

Mr. Ackerman (Utica, N. Y.), said no accounts were billed at longer than quarterly intervals, and if no reading could be obtained, it had been found preferable to bill an estimated amount rather than a minimum charge. This, to prevent the next bill from being disproportionately high. Checking of meters in place by means of a cubic foot measure was described by Mr. Oakman (Needham), as preferable to removal. The "g" meter-master designed to record every detail of consumption to show time of draft, shut-offs, amount of flow, etc., was highly commended as such a record is of aid in convincing owners.

Topic 3. "How do you explain the good qualities of your water to the average layman?"

Mr. Oakman said it is important to explain how the condition of the consumers' own pipes may cause tastes. Temperature conditions, carbon dioxide, and pH of the water are possible causes of objectionable conditions. Mr. Taylor (New Bedford), believed the explanation must fit the customer's intelligence and said they usually limited it to indicating the advantage of soft water which unfortunately was also corrosive water.

Mr. Ackerman mentioned a novel method of keeping consumers informed of water characteristics through newspaper advertisements to prevent them from requiring individual attention. Soft water is a very misleading term, and consumers accustomed to a certain hardness may even object to softening, according to his experience. Members discussed at some length the possibility of defective electrical grounding causing tastes in the water and corrosion of pipes. It was indicated that corrosive quality of the water should be studied before going in for copper-service pipes.

Technical Program

"Operating Experiences at the Salem and Beverly Filtration Plant," by Robert P. Johnson, Superintending Chemist, Beverly, Mass.

The construction of this new filtration plant, in operation since Nov. 1, 1935, was described and pictured by means of slides. Water is obtained from two sources, the first a 55 m.g. shallow reservoir supplied from peaty meadow land. The water is polluted, has a swampy odor. The second supply, Ipswich River, drains a populated watershed, has high color and bacterial content. Wash water from filter cleaning operations is run to lagoons and drains back to the lake.

Paddles are used for mixing alum and operate at 1 to 2 r.p.m. Water has a color of 24 to 70 p.p.m., coagulates readily between pH 5.4 and pH 6.7 with an alum dose nearly proportional to color present. Alum has varied from 1.1 to 1.8 gr. per gal., with 1.5 gr. per gal.

as a year's average. Probably the greatest difficulty had been taste and odor control in which little or no success had been had with activated carbon treatment in the absence of heavy prechlorinating.

When it became necessary to increase filtration rate from 125 m.g.a.d. to 140 m.g.a.d. settling time decreased from 4 to 3.5 hours and the average length of filter runs became 15 hours. Wash water requirements are 4 to 6 per cent of filtered water. The difficulty of plant operation is attributed to three causes: Small size of filter sand, algae growths, and the fact that the load applied to the plant is not uniform. The substitution of soda ash for lime as corrective treatment caused an apparent sloughing off of pipe deposits in power plant boilers, and lime was resumed as the preferred treatment.

Distribution system pipes were coated with slime, and while chlorinated water left the plant in a sterile condition, a chlorine residual could not be maintained in the system. Chloramine treatment was started with a 1 to 4 ammonia to chlorine ratio. Finally a 1 to 2 ratio was adopted and within two weeks had penetrated through all the mains but not to dead ends. Flushing was resorted to and now a dose of only 1.5 lb. chlorine and 0.75 lb. ammonia per m.g. gives a residual of at least 0.01 p.p.m. in all parts of the system.

Reservoir treatment with copper sulphate in July and November of 1936 was unsuccessful. One to three p.p.m. of carbon applied in the mixing basins showed no advantage. Finally prechlorine treatment (5.5 lb. per m.g.) proved able to kill the organisms, and following this treatment with carbon to remove the odor produced, showed the greatest beneficial results.

"Experiences with Chlorinating New Water Mains and Other New Works," by Francis H. Kingsbury, Senior Sanitary Engineer, and George O. Adams, Chief of Laboratory, Massachusetts State Department of Health.

While other reports have been published concerning pollutional possibilities of jute packing, the extensive study of such contamination made by these authors proved a distinct contribution to the subject. Main sterilization in new construction is recommended to municipalities and advice on the use of chlorine or chlorine compounds is given. Uniform results, however, prove difficult to secure, and since the joint packing material is the only substance permanently existing in pipes its use was studied.

Some mains have required only one day for disinfection, others from seven to as high as 17 days. Both hydrant and tap samples had been taken to check sampling points.

Finally a number of jute samples were studied. A comparison of 14 available types, made by soaking 1 gram of the sample in 100 cc. of sterile water and plating, showed counts of coli-aerogenes types ranging from 10,000 per gram up to one million per gram of sample. After allowing samples to stand for 3 days the counts had increased in the case of the 10,000 per gram to ten million and the others were correspondingly higher. Even by boiling, drying or autoclaving the jute sample to sterilize it, if it was reinfected with tap water or polluted Lawrence River water the coli-aerogenes group of organisms would grow. In fact, jute made a media nearly as good as nutrient agar!

Experiments were performed to duplicate conditions existing in mains by keeping braided jute in a 10 p.p.m. chlorine solution and removing samples after varying periods for examination. After even two weeks' exposure only slight decreases were noted. Unbraided jute, however, would disinfect promptly. Jutes treated with tar, wax, and oil, were studied. With one exception, the tarred jute was free from coli-aerogenes organisms, only one of the waxed jutes was not contaminated, the oiled jute had high counts. Since some jutes contain coli contamination and since all specimens seemed to support coli-aerogenes growth, it was decided to study its effect on a pathogenic organism. A typhoid strain grew well on jute media and this indicated that earlier reports, which tend to minimize bacteriological results, are too liberal in opinion.

The authors conclude that manufacturers must develop means of making the product satisfactory. Tarred jutes, the best of those studied, might have the objectionable feature of producing tastes and odors in the water.

"Chlorination of a Cambridge Main," by Fred E. Smith, Chemist, Cambridge Filtration Plant, Cambridge, Mass.

In improving this distribution system some 10,900 ft. of 30 inch main was laid and much pollution was possible during construction. In one case a sewer line was broken and sewage flowed into the trench. A portable chlorinator with a capacity of 40 lb. per 24 hours was used but, as water supply was not readily available, it was necessary to supply gaseous chlorine to the line. The pipe was chlorinated in sections, since the main was filled in this manner to test for leaks. This procedure resulted in over-chlorinating the section near the point of addition, as only a small blow-off was opened to move the water. Back pressure in the pipe made addition of chlorine difficult.

An average dose of 12 p.p.m. chlorine was applied and after flushing examination of the water showed counts of 1 or 2 per cc. with negative coli-aerogenes tests. Practically all residual chlorine had been removed and when the main was put in service no complaints were received.

"Water Chlorination Experience," by Frederick O. Almquist, Senior Sanitary Engineer, Connecticut State Department of Health.

In a most comprehensive manner Mr. Almquist discussed the safe and efficient application of chlorine in connection with water supplies of his state. This paper is worthy of note by all designers and operators of water plants. Connecticut experience has shown hydraulically operated pumps, where water pressure must be developed, to be preferable to electric motors. Safety in housing and heating chlorinating equipment was discussed in detail, as were the operating, repair, and testing facilities necessary to dependable disinfection.

In polluted water, taste and odor must be held secondary to maintenance of an adequate residual. In Connecticut the chloramine process had generally been found preferable to simple chlorination. Chlorine used alone has often caused tastes in water supplies of that state during the spring and fall turnovers of reservoirs which is accompanied by an increase in organic content of the water. As a point of interest in connection with imaginary consumer complaints, Mr. Almquist noted that chlorine has never been actually found responsible for killing goldfish, these fish being highly resistant to chlorine.

The use of chlorine in the sterilization of new mains was discussed, and the standard recommendation, when HTH or Perchloron is used was noted. Using 0.5 lb. of either material per 100 ft. of pipe will give 18 p.p.m. of chlorine in 6 inch pipe or 3 p.p.m. in a 16 inch pipe. It had been felt best to use this uniform amount rather than to attempt to vary the dose with the pipe size and assume the risk of inadequate disinfection.

PRACTICAL HYDRAULICS

III. Measurement of a Head on a Weir [1]

By P. S. WILSON*
New York, N. Y.

This is the third of a series of articles being presented by the author on selected phases of hydraulics from the viewpoint of the practical water-works operator.

Mr. Wilson's experience as a superintendent of water works and later as superintendent of operations of all Community Water Service Co. plants, enables him to contribute material of practical value.

His next article will deal with Float-Gages in measuring and recording.—Editor.

THE measurement of flowing water by means of a weir depends in turn upon the measurement of the *head* of water on the weir. Having determined the weir formula to be used, depending upon the design of the weir crest, the presence or absence of end contractions and any other fixed conditions, the recorded flow then depends upon the head. The head is the single remaining variable quantity. It is the quantity which is actually observed and measured in the field, the desired knowledge as to the amount of water flowing being then computed by the use of the formula, table or diagram. It is assumed in this discussion that the flow over the weir is not affected by backwater from below.

The head on a weir is the difference in elevation between the crest of the weir and the surface of the water in the pool upstream from the weir. Figure 1 is a vertical cross section through a sharp crest weir with water flowing over it under a head indicated by (h). The shape of the upper and lower water surfaces shown in this figure have been determined by measurement and have been found to have forms similar to these, regardless of what the head is, so long as the weir has a sharp crest and a vertical upstream face. Under special conditions at low heads the water may, however, cling to the downstream face of the weir.

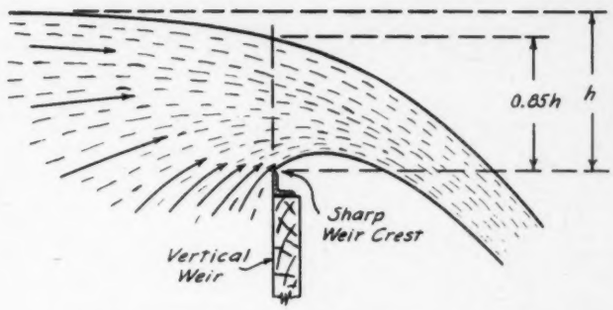

Fig. 1—Characteristics of Water Flow Over a Weir

Figure 1 shows clearly the fact that in this general case the water only touches the crest along the one sharp edge and then leaps free. The arrows showing the converging stream indicate the reason for the shape which the lower surface of the water is found to take. There is one very important fact to be noted from Figure 1—namely, the upper surface of the water starts to curve downward before it reaches the weir. This results in the depth of water at the weir crest actually being only about 85/100ths of "h" (expressed as 0.85h)—the condition which makes it necessary to measure the height of the water surface at some distance upstream from the weir when determining the head. The height of the water surface should be measured at a point located upstream from the weir *a distance at least equal to three times the maximum head* to be encountered.

Measuring Gages

The type and design of gage to be used to determine the water level depends upon the accuracy desired and the conditions under which it will operate.

The Staff-Gage

The simplest and most commonly used type of gage consists merely of a strip of wood or metal with the

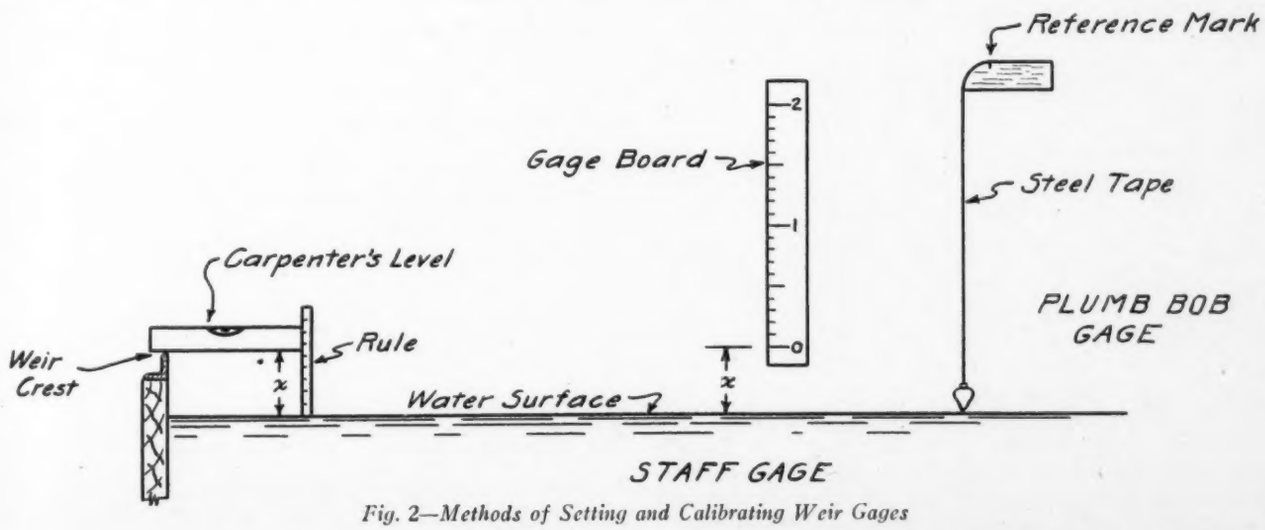

Fig. 2—Methods of Setting and Calibrating Weir Gages

[1] Other articles by Mr. Wilson, dealing with measuring of flows by weirs, are to be found in the April and June, 1934, issues of WATER WORKS AND SEWERAGE.

*Assistant to the Secretary of the American Water Works Association.

necessary graduations marked upon it. A section of a carpenter's rule or a surveyor's rod may be used if adequately waterproofed by varnishing. One of the best forms of gage board consists of a vitreous enameled ware metal plate mounted on a wood plank. The graduations and figures are baked into the enamel. Gages such as these, often called staff-gages, if well graduated and carefully read will enable the water level to be determined to within about 0.01 feet, equivalent to about 1/8 inch. This is sufficiently accurate for most purposes other than studies requiring laboratory refinements. One of the greatest disadvantages of this type of gage, however, is the necessity for locating the observer's eye near the water level when taking a reading. This is not always convenient. Care must be taken to read at the true water surface and not the height to which the water surface curves upwards where it wets the gage.

When mounting a staff-gage great care is needed to insure that the zero of the gage is exactly level with the crest of the weir, and that it remains so. A small error in this respect will cause a large error in the results, particularly at low heads. Moreover, this error will always be in the same direction and will not tend to correct itself or be compensated for by other errors.

By the careful use of a surveyor's level a gage may be set with sufficient accuracy. If a surveyor's level is not available then the water surface itself may be used in the manner indicated in Figure 2. Choose a time when the water surface is not rising or falling too rapidly and preferably when it is lower than the weir crest. By means of a carpenter's hand level and rule measure the distance (x) down to the water surface from the weir crest. Then measure up from the water surface at the gage location and set the gage zero the same distance (x) above the water level as the weir crest was found be. Then, afterward, such gages should be regularly checked to be certain that they have not been moved, and that the zero point is correct.

Plumb-Bob Gage

Another form of gage is known as a plumb-bob gage. It consists of a graduated steel tape with a heavy plumb bob on its end. It is used to measure from a fixed reference mark, above water level, down to the water surface. By allowing it to swing slightly the contact of the plumb bob with the water surface may be very accurately noted. This naturally assumes the water surface to be smooth. The plumb-bob gage may be most accurately read if the tape is run over a curved block of wood, mounted permanently above the water, which has the reference mark fixed on its upper surface, as indicated in Figure 2. The zero reading on this type of gage may be determined by measuring down to the water surface from the weir crest as shown in Figure 2 and applying the correction factor determined by a simultaneous reading of the tape.

Chain Gage

A similar type of gage known as a chain gage is often used. For the tape a chain running over a wheel is substituted. With this arrangement the position of a marker attached to the chain above the wheel is read along a horizontal scale. This type of gage is not so accurate as the former and it is not advised for weir readings except in the case of rough work or high heads. It is often used for river heights where accuracy within about 0.05 feet is generally satisfactory.

With all types of gages difficulty is introduced if the water level is disturbed by waves or surges. In the case of the gages above described this can only be overcome by the skill and patience of the operator in mentally averaging the indications while observing them over a short period. Practice can develop considerable skill in doing this.

Float-Gage

Probably the most accurate type of gage, if well designed and constructed, is a float gage. Besides its accuracy it also has other advantages. Difficulty in reading due to waves and surges may be most readily overcome with the float type gage which is readily adapted to the use of an automatic recording mechanism. There are a number of different arrangements of float gages and several important features to be considered in their design which will be discussed in an article to follow.

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Meetings Scheduled:

March 18*—BOSTON, MASS. (Hotel Statler).

New England Water Works Association. Sec'y, Frank J. Gifford, 613 Statler Bldg., Boston, Mass.
*(Also April 18th at Hotel Statler.)

March 25-26—INDIANAPOLIS, IND. (Antlers Hotel).

Indiana Section, A. W. W. A. Sec'y-Treas., J. A. Bruhn, Box 855, Indianapolis, Ind.

March 30-April 1—OCALA, FLA. (Camp Roosevelt).

Florida Section, A. W. W. A. Sec'y, J. R. Hoy, W. & T. Co., 404 Hildebrant Bldg., Jacksonville, Fla.

April 5-7—CHATTANOOGA, TENN. (Hotel Patten).

(a) **Southeastern Section, A. W. W. A.**

(b) **Kentucky-Tennessee Section, A. W. W. A.**
Joint meeting.

(a) Sec'y-Treas., W. H. Weir, State Dept. Health, Atlanta, Ga.

(b) Sec'y-Treas., H. D. Schmidt, State Dept. Health, Nashville, Tenn.

(This notice supersedes previous notices of separate meetings. The two sections will combine to hold a "Little Convention" at Chattanooga.)

April 14-16—MONTREAL, CANADA (Windsor Hotel).

Canadian Section, A. W. W. A. Sec'y-Treas., A. E. Berry, Chief Engr., Ontario Dept. of Health, Parliament Buildings, Toronto, Ont.

April 19-22—LEWISTOWN, MONT. (Hotel Burke).

Montana Section, A. W. W. A. Sec'y, H. B. Foote, Chief Engr., State Board of Health, Helena, Mont.

April 22-23—PHILADELPHIA, PA. (Hotel not selected).

(a) **Four States Section, A. W. W. A.**

(b) **Penna. Water Works Operators' Assn.**
Joint meeting.

(a) Sec'y-Treas., Carl A. Hechmer, Washington Suburban San. Distr., Hyattsville, Md.

(b) Sec'y, I. M. Glace, 22 S. 22nd St., Harrisburg, Pa.

April 29-30—SPRINGFIELD, ILL. (Abraham Lincoln Hotel).

Illinois Section, A. W. W. A. Sec'y, W. D. Gerber, Engr., State Water Survey, P. O. Box 232, Urbana, Ill.

May 6-7—WILMINGTON, DEL. (Hotel Dupont).

Maryland-Delaware Water & Sewerage Assn. (11th Annual Meeting). Sec'y Treas., A. W. Blohm, 2411 N. Charles St., Baltimore, Md.

May 20-22—VICTORIA, B. C. (Empress Hotel).

Pacific Northwest Section, A. W. W. A. Sec'y, Fred Merryfield, Prof. of C. E., Oregon State College, Corvallis, Oregon.

June 4-5—UTICA, N. Y. (Hotel not named).

N. Y. State Sewage Works Association. Sec'y-Treas., A. S. Bedell, State Dept. Health, Albany, N. Y.
(Manufacturers' exhibits a feature of this meeting).

June 7-11—BUFFALO, N. Y. (Hotel Statler).
American Water Works Association (Annual Convention). Executive Secretary, Harry E. Jordan, 29 West 39th St., New York City.

June 21-25—State College, Pa. (Penna. State College).
Pennsylvania Sewage Works Association (June 21-23). Sec'y, L. D. Matter, State Dept. Health, Wilkes Barre, Penna.
Pennsylvania Water Works Operators' Assn. (June 23-25). (10th anniversary.) Sec'y, I. M. Glace, 22 S. 22nd St., Harrisburg, Penna.

FLOW STUDY ON A "SEPARATE" SANITARY SEWER SYSTEM

By V. W. WILLITS

Cons. Engr., Los Angeles, Calif.*

AN IDEAL "separate" system of sewers, of course, is one from which storm water of great seasonal or annual fluctuation is entirely excluded. These so-called "separate" systems, as is to be observed, have not attained that ideal.

The chief effects of winter rains upon the flow, in sanitary sewers, where entirely separate drains for storm water are maintained in one major city, are here set forth and picturized.

In Southern California the short torrential rainy season makes imperative a separate system of storm water trunks where accumulated quantity becomes too great for surface gutters, so that sanitary sewage proper can be moved with reasonable cost and efficiency during the remaining three-quarters of the year. Therefore, Los Angeles gives constant attention to means of diverting from its sanitary sewers the runoff from public and private bathing pools, large laundries, and lawn irrigation, in addition to rainfall.

The accompanying parallel graphs reveal, for the years 1926, 1927, and 1928:

(a) Average weekly maximum rate of outfall sewer discharge, by months, in second-feet.
(b) Monthly average rate of domestic water consumption in second-feet from Los Angeles' chief water supply system.
(c) Monthly rainfall, in inches, at the Los Angeles recording stations.
(d) Mileage of sewers, population and extent of street paving.

The years shown contain the highest, next highest, and a lowest rainfall record for the period during which venturi records of the outfall sewer exist.

The derivation of these graphs involves the assumption of a regularly increasing rate of solely household and commercial consumption of water (excluding lawn irrigation and other summer extras), which rate is equal to the total rate at the winter minimum; and that the simultaneous sewage flow rate from solely household and commercial sources follows variations parallel to those of the water consumption, being equal to the total flow at the dry weather minimum.

A study of the diagrams shows 100 second-feet to be the maximum storm water increment, occurring with the maximum rainfall in February, 1927. The deduced data for comparison, in forecasting the probable pipe capacity required for storm water increment to sanitary sewage, are as follows:

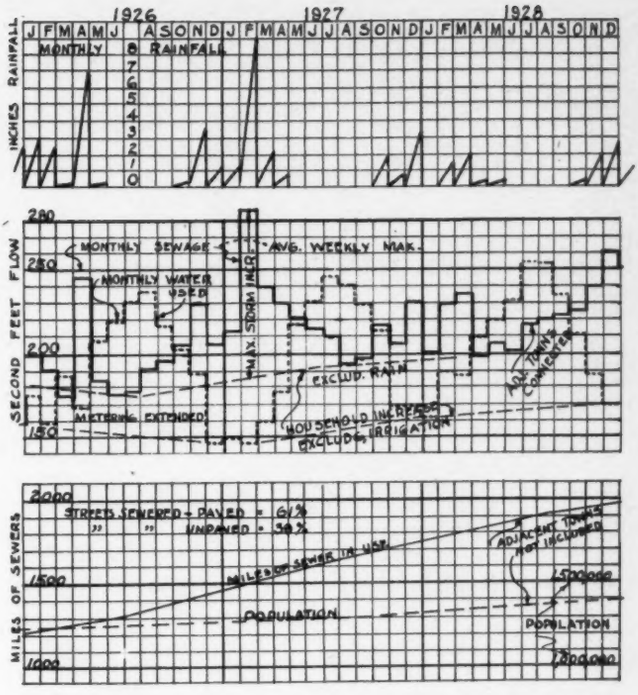
Area sewered, about 50 square miles. Miles of sewer in paved street, 945; and in unpaved, 605; total, 1,550 miles.

The outfall sewer is 10.5 ft. high, semi-eliptical. Its capacity, flowing full, is 430 second-feet.

$$\frac{\text{Cross-section for Storm Water}}{\text{Cross-sec. for Sanitary Sewage}} = \frac{75}{430 \text{ less } 75} = 0.2113$$

and $\dfrac{75 \text{ sec.-ft.}}{50 \text{ sq. mi.} \times 640} = 0.00234$ second-feet per acre.

*Formerly with the Bureau of Engineering, City of Los Angeles.



Rainfall and Increments of Storm Water to Sanitary Sewage Flows and Water Consumption. Lower Graph Pictures Population Served, Sewer Mileage and Percent of Streets Paved.

The sanitary sewage proper is:

$$\frac{185 \text{ sec.-ft.}}{50 \text{ sq. mi.} \times 640} = 0.0058 \text{ sec.-ft. per acre, and}$$

$$\frac{185 \text{ sec.-ft.}}{1{,}275{,}000 \text{ (population)}} = 0.00015 \text{ sec.-ft. per capita of 40 per acre.}$$

This represents a composite of every class of residence, apartment, and hotel, and of retail and wholesale business, and of manufacturing, packing, oil refining, motion picture and steel industries.

Manholes are predominantly of standard type, 2 ft. diameter, with a ¾-inch hook hole and one or two rim notches. About 1 per cent were of very old type and perforated for about 10 per cent of lid area. About ¼ per cent had no hook hole, but two rim notches. Spacing of manholes is 330 ft. approximately, except in sharp curvature representing about 5 per cent of the mileage; and, for about 2 per cent of the mileage the spacing averages 2,500 feet.

The probable total maximum approximate storm run off for this case, which involves 160 square miles of sewered area having a clayey soil sloping on the average 35 ft. per 1,000 and 20 per cent roofed and paved, for a 2 hour rainfall averaging 0.33 inches per hour, is (by Mc.Math) 0.03 sec.-ft. per acre, or 3,072 sec.-ft.

The proportion leaking to the sewers can, thereby, be calculated as being:

$$\frac{100 \text{ sec.-ft.}}{3072} = 3 \text{ per cent (approximately).}$$

[In a forthcoming article, A. M. Rawn, Asst. Chief Engr., Los Angeles County Sanitation Districts, will reveal the results of careful studies which reveal the surprising volumes of storm water which enter sanitary sewers through or around man-hole lids of various patterns.—Ed.]

EDITORIAL

Sewage Treatment Progress From Two Sides

IN this issue are two important articles pertaining to sewerage and sewage treatment. That by Professor Hyde constitutes an able and valuable recounting of the more important developments in the treatment of sewages. Of special interest are the author's enlightening comments on present day trends in sewage and wastes disposal. The other article, that by Messrs. Klassen and Wisely which is a worthy companion contribution, recounts effects and results from "The Newer Methods of Sewage Works Financing," as these have been put to advantageous use in a state already known for its progress in pollution abatement.

In short, Professor Hyde's review is stimulating and informative in respect to those advances which go to improve the technical and economic aspects of sewage and wastes treatment. Klassen and Wisely's contribution serves to show how the all important problem of financing sewerage betterments and new works and, most important, the effective operation and maintenance of the latter, has been largely solved by the newer and recently legalized methods of raising funds for sewerage betterments. Such progress, as is brought to light in the numerous installations of treatment works during the past two years or less in the smaller communities of Illinois, heretofore unable to finance such betterments, is highly impressive.

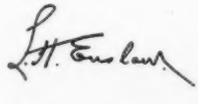
The most impressive revelation in the Illinois experience is, to this writer, the flexibility made possible in financing sewerage betterments through the now legal method of operating sewage works as a public utility in conjunction with the communities' No. 1 utility—its water works. While the Illinois results serve to focus attention on the merits and workability of the scheme of combining water works and sewerage under a single management, the plan is not entirely new. For some time the trend in other states has been in this direction where legally permissive. Progress in sewerage betterments in North Carolina, for instance, can be definitely traced to legislative acts which permitted combination schemes of financing and operation of the water works and sewerage departments. To many it is not known that several of the larger cities, such as Cleveland, Dayton, Dallas, Columbus, Providence, have for some time operated their twin utilities, water works and sewerage, as the interlocking and interdependent public service enterprises that they are. The Illinois experiences are none the less impressive in showing the practical workability and, most important, the marked acceptability of the newer scheme of financing sewerage betterments for the smaller community. Undesirous of or unable to issue general obligation bonds, these municipalities now find the legalized revenue type of bond an easy to issue and worthy security in the eyes of finance groups.

Not the least value in the service charge method of financing sewage treatment works is the fact that the service charge must be ample to adequately maintain and operate the works. In turn, this means the availability of funds for improved operation and a higher class of operation and management by qualified operators. With service charge methods of financing, evidence is already available to show that operators in responsible charge are better qualified men who are being more adequately compensated.

With impetus being given sewage treatment as the natural consequence of the basically more sound, and easier and less disturbing methods of financing to the tax-paying public; with present day trends toward more flexible, dependable and technically and economically improved methods, as recounted in Professor Hyde's review; with the trend toward, and possibilities of, combining the two interlocking hydraulic utilities, water works and sewerage, under a single general management; with more adequate and better compensation made possible to management and operating personnel—what is in sight for sewerage betterments? If all concerned will keep the possibilities now at hand before them, and seek to further advance that progress so effectively gotten under way in the past two years, we shall see the lamentable deficiency in sewage treatment markedly reduced in the next few years. What's more, we shall see existing works manned and operated more efficiently by better qualified operators who are more adequately appreciated and compensated.

Along with advancing municipal efforts at stream cleansing a natural consequence is expected in the nature of advances in industrial waste treatment. Looking forward to the latter, some form of Federal anti-pollution legislation seems to be justified. Unlike the case of municipal waste treatment, where financing can be more equitably arranged and where arguments of competitive advantage do not enter, the cost of waste treatment to industrial establishments must enter the cost of the manufactured products. The state which has not an ample restraining law, or fails of enforcement of such a law, may find itself the "dumping ground" of industry unless some uniformity in state anti-pollution legislation is brought into being. Like Federal quarantine and public-health regulations some pattern of Federal "standards," supplemented by more specific drainage basin requirements, seems highly desirable in industrial pollution control if uniformity in requirements, so-called hardships, or lasting progress is to be had in all sections.

We can see no alternate to a general Federal jurisdiction and paternalization in any effective solution of America's stream pollution and water utilization problems. In the meantime sewage treatment progress will continue and with technical and financing advances much can be accomplished which seemed practically impossible in the smaller communities in the past, and only through efforts divorced from other municipal functions in many of the larger cities.



Maintain Design Capacity

Barrett Water Works Enamels form a lining in pipe so smooth that the capacity of a system is maintained for years to come. They increase the coefficient of flow, and eliminate tuberculation. No other material offers greater resistance to moisture absorption than coal-tar pitch, which forms an efficient protection to electro-chemical corrosion, soil acids, alkali and earth currents.

THE BARRETT COMPANY
40 Rector Street New York, N.Y.

Barrett
WATER WORKS
ENAMELS

FIELD SERVICE

The Barrett Company maintains a Pipe Line Service Department to assist engineers in all coating problems, and also has available Field Service men whose assistance is offered where Barrett's protective coatings are used. Inquiries are invited.

44" diameter steel pipe
City of San Francisco, Cal.

EQUIPMENT NEWS

"Pozzolith"

Master Builders Company of Cleveland have had much to say recently about their "POZZOLITH"—all because of the glowing letters of praise from engineers and architects. Many engineers know of the attributes of "POZZOLITH"; but, for the benefit of those who do not, the material is a gelatinous liquid which, when added to concrete mix in the ratio of 1 gal./cu. yd. of concrete, chemically combines with the free lime, changes the physical properties of the mortar and the chemical and physical properties of the concrete produced. *Results*:—Increased fluidity and workability of the mortar mix, with a reduction of 15 to 20 per cent in water requirement—taking less than 18 lbs. of water per bag of cement for complete hydration. *Attendant Effects*:—A mix more easily and uniformly placed; a denser, harder stronger concrete. *End Results*:—Concrete with minimum porosity which stands up against severest frost action; concrete with less shrinkage and less soluble salts (lime, etc.) to produce subsequent porosity due to leaching; consequent higher resistance to sulphate attack (crystallization spalling), and swelling and disintegration due to so-called sewer-gas attack—the latter being in reality sulfuric acid attacks due to the sulphide bearing sewage gas oxidation above water line.

All of the above claims and more are effectively exhibited in an illustrated manner, and supported by engineers' statements, in a recent brochure "POZZOLITH," which is to be had for the asking from Master Builders Company, 7061 Euclid Avenue, Cleveland, Ohio.

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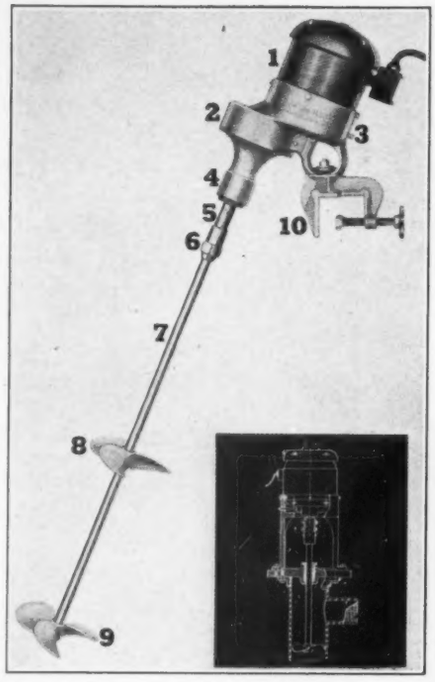
"Lightnin" Mixing

With the ever increasing appreciation of the value and money saving effects secured from flash-mixing in the coagulation of water, sewage, trade wastes and sludge, and chlorination of sewages, it is especially timely to say something of Mixing Equipment Company's "LIGHTIN" Mixers and Agitators, long established with industrial users. Not yet well known in the water and sewage fields, these handy mixers have recently gone into several plants as chemical dissolving and mixing devices. However, this equipment deserves attention as flash agitators for the purpose of quick and effective and economic distribution of coagulant, chlorine, lime, etc., throughout the menstrum being treated.

In a great variety of styles and sizes "LIGHTNIN" Mixers and Agitators are available, as the result of many years adaptation in the industrial field. Starting with laboratory models, the line contains many portable sizes, and closes with large heavy duty stationary sizes. Speeds and diameter of propellers and setting angle provide variables to meet conditions imposed. The unit can be set into a down pipe, by inserting a "leg" in the line, or set horizontally to pass through the side wall of a chamber of tank. The flexibility of adaptations and special features can best be appreciated by examination of the recent Catalog B, 53—"LIGHTNIN" Mixers—Address Mixing Equipment Co., Inc., Rochester, New York.



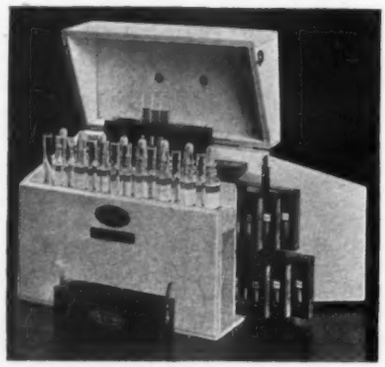
Portable Geared "Lightnin" and (Inset) the Stationary Pipe Line Model

▼

Taylor's New Long Range Comparator

W. A. Taylor and Company, well known laboratory supply house of Baltimore, announce a new "Long Range Slide Comparator" especially designed to meet the need for a combination portable and laboratory set covering pH ranges wider than those covered by two indicators. It comes with various combinations of indicators and color standard slides. Starting with 3, can be expanded to 9 indicators and requisite standard slides to cover any part or the whole pH range 0.2 to 13.6. The light weight case, 6 x 9 x 11½ inches in length, has a safe carrying handle. The color standards are guaranteed against fading for five years.

For detailed description of this set, and variation of indicator and slide combinations, with price schedule of each—address, W. A. Taylor and Company, 872 Linden Ave., Baltimore, Md.



Long Range Slide Comparator

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New Tanktrol

In their new catalog "Automatic Controls for Water Systems and Sewage Works," Automatic Control Company of St. Paul, Minn., announce the new E-2 TANKTROL which supercedes their older E-1 and D. W. TANKTROLS. It is a pressure-type pump control for water systems having high level reservoirs, stand pipes or elevated tanks.

The desirable features of each of the older units have been combined in the new TANKTROL. Added has been the featured and exclusive SURGETROL (a thermal-electric hook-up) which prevents surges and brief pressure disturbances from causing the pump motor to cut in or cut out due to the temporary "false-alarm." For deep well turbines, back-spin protection is also given. Equipped for full range, with high and low level settings, its accuracy has been increased.

New Tanktrol

In the same catalog improved Types "M," "T," and "D," SELECTROL units for sequence or program control of multiple combinations of sewage pumps, equipped with variable or single speed motors, are illustrated and described. For hydropneumatic water tank installations two types of DUOTROLS are offered. For the complete new Catalog C-1, address Automatic Control Company, 2590 University Ave., St. Paul, Minn.

▼

Dresser 65's Big Brother Now Has Little Sister

The accompanying illustration effectively confirms that old Chinese proverb—"One picture is worth a thousand words." It reveals all there is to the small Dresser 65 fittings, in make-up and simplicity of application to pipe sizes from ½ to 2 inch—with plain or threaded ends, and rough or smooth surfaces. Slip it on, screw it tight (or tighter)—that is all there is to

ST. LOUIS does it again!

THE NATION OVER!
Cities like these are establishing the trend to Dresser Couplings:

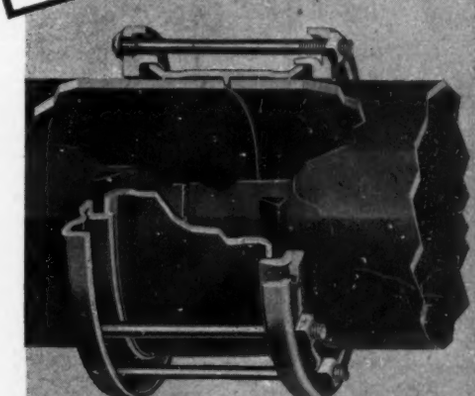
Cincinnati, Ohio
Cleveland, Ohio
Danbury, Conn.
Sheridan, Wyo.
Trenton, N.J.
Washington, D.C.

You'd have to tramp nine miles to cover the entire length of St. Louis' new water conduit! The diameter of 60" throughout is impressive, too! A previous 60"-54"-48" conduit, recently completed, is even longer—13 miles! Both are completely joined with Dresser Couplings!

FIVE REASONS WHY MODERN WATER LINES ARE DRESSER-COUPLED:

1. PERMANENT TIGHTNESS—proved for 50 years, on 150,000 miles of pipe.
2. FLEXIBILITY—normal pipe movements—present in every line—are absorbed.
3. SIMPLICITY—joint parts are "factory-made"; ordinary labor can install.
4. STRENGTH—predetermined; joints safely withstand any specified pressure.
5. TRUE ECONOMY—a truly lower joint cost throughout the life of the line.

Write for our General Catalog No. 36.

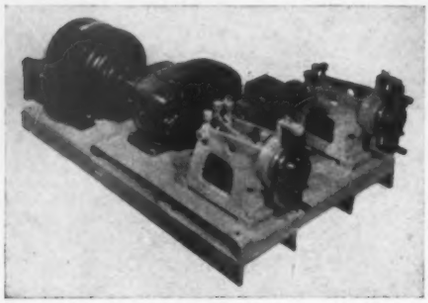


Cutaway view of Dresser Style 38 Coupling, showing working principle. Note that plain-end pipe is used. The resilient gaskets, flexing with the pipe, safely absorb pipe movements.

THE MODERN TREND IS TO DRESSER COUPLINGS

S. R. DRESSER MFG. COMPANY, BRADFORD, PA. • *In Canada:* Dresser Mfg. Company, Ltd., 60 Front St., W., Toronto, Ont.

% CHEMICAL FEEDERS %



Much Ado About "Industrial Effluents"

Industrial Wastes **may include everything from floor-sweepings, or steel filings to slag. The wastes that most concern sewage magazine readers are the liquid wastes from Industry — which we call "Industrial Effluents".**

Right now there is much ado about these effluents and the river and stream pollution they cause.

Izaak Waltons arise to protect the fish—seafood industries to protect their oysters—civic associations decry the ruination of bathing and our other natural stream resources—private and municipal water companies protest the dumping of "odor and taste" into water supply sources—Boards of Health arise to maintain the public health by correcting the effluents from Industries.

Much We Do About "Industrial Effluents"

%Proportioneers% Devices are suitable for accurate feeding of industrial effluent correcting chemicals:

Coagulant Chemicals (Ferric, Alum, etc.)—Sterilizing Solutions (Hypochlorite, chlorine solutions, etc.)—PH control Chemicals (Soda ash, lime, sodium silicate, etc.)

Chemical Plants, Dye Plants, Dairies, Canneries, Breweries and the host of industrials who want to stop stream pollution most effectively and at modest cost are invited to incorporate our devices into their specifications for plants to correct industrial effluent.

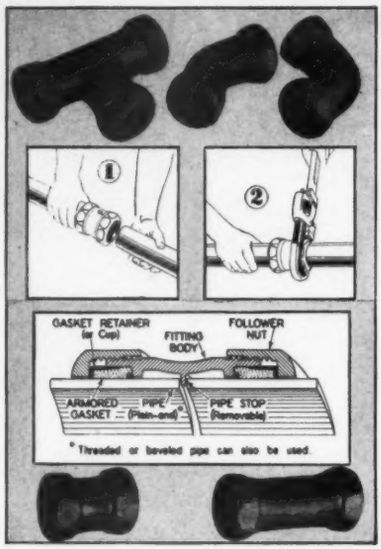
Write us for bulletins, regarding Chlor - O - Feeders, Ferr - O - Feeders, Amm-O-Feeders, Alum-Feeders—Any-kind-of-Feeders.

% PROPORTIONEERS % Inc.

Associated with Builders Iron Foundry

9 N. Codding Street

PROVIDENCE, R. I.



Dresser Compression Fittings

tell about its application. In make up, the principle is that of a stuffing box with packing of live rubber gasket, with proven long life, which is followed by a tightening (spreading) gland and nut. The tighter the follower nut the tighter the packing around the stem—in this case the pipe. For a rough or pitted pipe it has to be made up a little tighter than for smooth,—that's all. The gasket is "armored" to stand up against "strong-arm" treatment at the end of the longest handled Stilsons. The several available Type 65 Compression Fittings are pictured.

We wanted to know what practical operators and superintendents thought about them. We found that they were not as new as we had once thought. But, learned of plenty reasons why these fittings should be called to our readers' attention on this page, as labor and time saving gadgets—especially ideal for repair, replacement and emergency jobs. Specific reasons; to take up vibrations, expansion and contraction, provide flexible joints, to set in removable pipe lengths in corrosion observations at various points—etc., etc., and etc.

To learn what "etc. and etc." covers a "sample line" of these utility and emergency fittings might well be carried in every tool box and maintenance or repair truck. These "little sister" fittings have come to join the "big brother" Dresser Couplings, which have become so popular in the water works and sewerage field for jointing larger pipes. For descriptive literature or a "sample" fitting, address S. R. Dresser Manufacturing Company, (Dept. W. & S.), 826 Fisher Ave., Bradford, Pa.

▼

"Weldmaster" Improved Welding Torch

The Modern Engineering Company of St. Louis, Mo., makers of Meco Oxy-Acetylene Welding Equipment, are offering a new ultra-lightweight welding torch known as the "Weldmaster." Made of a new alloy, it weighs only 17.5 ounces with standard tip attached; is claimed to be the lightest torch on the market, and is perfectly balanced for flexible manipulation with a minimum of effort.

The circle-mixer, employed in all Meco torches, has been improved and its capacity increased. A rifle-smooth bore of all passages contributes to the production of ideal flame characteristics under all operating circumstances in the full range of welding practice. Other exclusive features of the "Weldmaster" are: spring-tension equipped wheel handles to permanently maintain flame adjustments regardless of rough handling; fluted wheel handles; grip is thin, with wide fluting.

For complete description and prices, address Modern Engineering Co., 3411 Pine Street, St. Louis, Mo.

▼

Personnel Changes in Clark Controller

The following appointments and staff changes have just been announced by W. H. Williams, Vice-President in Charge of Sales, Clark Controller Company and Sundh Electric Company of Cleveland.

O. L. Holcombe returns to the Philadelphia Office as District Manager, replacing E. A. Hurme, resigned. To the New York Office, Robert H. Hoge, for several years connected with General Electric Company. From the New York Office to the Pittsburgh Office, J. W. Hammann as Assistant to G. W. First, Pittsburgh District Manager. From Headquarters at Cleveland to Detroit Office, W. R. Uffelman. From the New York Office to Headquarters Cleveland, S. J. Nogosek, Sales Engineer.

▼

Saunders Becomes Permutit Sales Manager

Daniel J. Saunders has been named Manager of Industrial Sales for The Per-

Daniel J. Saunders

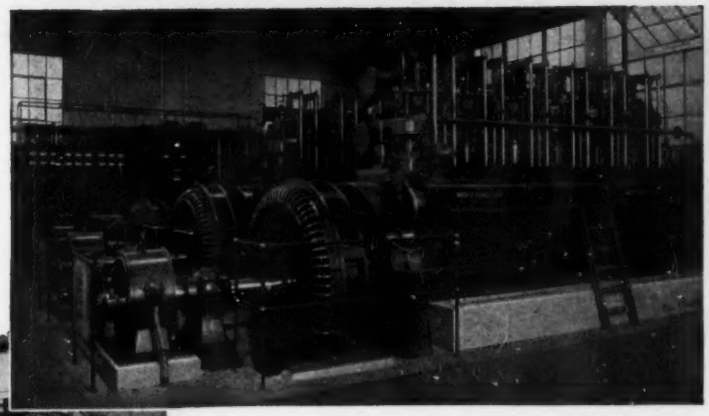
mutit Company, New York, manufacturers of water conditioning equipment. Mr. Saunders has been with the company for seventeen years, now being advanced from Assistant Manager of Sales.

▼

Jeffrey's Renner Appointed by A.S.M.E.

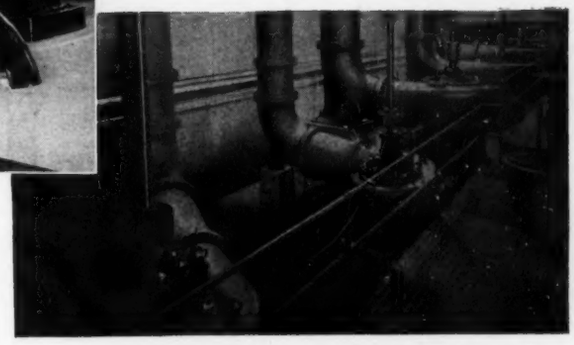
R. B. Renner, with the Jeffrey Manufacturing Company for the last 30 years as mechanical engineer, was recently made chairman of the executive committee of the materials handling division of the American Society of Mechanical Engineers.

COMPLETE WORTHINGTON SERVICE *for* FORWARD-LOOKING MUNICIPALITIES

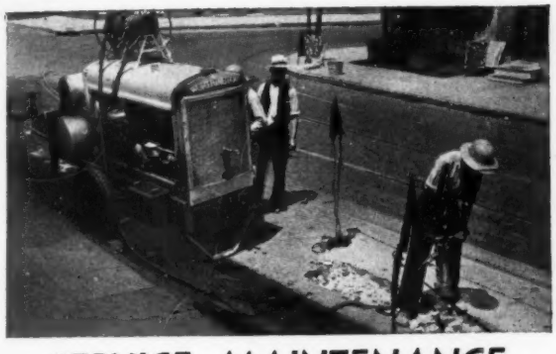


POWER AND LIGHT

WATER SUPPLY



SEWAGE DISPOSAL



SERVICE MAINTENANCE

METERING WATER SUPPLY

A COMPLETE line of water meters of every type is manufactured by Worthington-Gamon Meter Company, a subsidiary of Worthington Pump and Machinery Corporation.

Be sure to attend the
AMERICAN WATER WORKS ASSOCIATION CONVENTION
Buffalo, New York, June 7 to 11

IN hundreds of municipalities, a fast growing list of Worthington installations is justifying, by splendid operating records, the confidence of those responsible for their selection. Maintained operating efficiencies and continuous dependable performance of all types of Worthington equipment have brought substantial profit to progressive communities everywhere. This is but the logical result of the unsurpassed engineering skill built into every Worthington unit . . . made effective by a rigid policy to produce the best.

WORTHINGTON PUMP AND MACHINERY CORPORATION

General Offices: **HARRISON, NEW JERSEY** • *Branch Offices and Representatives in Principal Cities throughout the World*

WORTHINGTON

ATLANTA BOSTON BUFFALO CHICAGO CINCINNATI CLEVELAND DALLAS DENVER DETROIT EL PASO HOUSTON KANSAS CITY LOS ANGELES NEW ORLEANS NEW YORK PHILADELPHIA PITTSBURGH ST. LOUIS ST. PAUL SAN FRANCISCO SEATTLE TULSA WASHINGTON

IC7-14

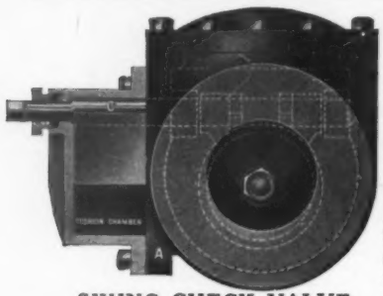
DEPENDABILITY

ALTITUDE VALVE

● ALTITUDE VALVE assures perfect water-level control in tanks, standpipes and reservoirs.

Always function without any water surge or shock due to efficient air and water cushioning.

Furnished with automatic, electric and manual control, and for single or double-acting service.



SWING CHECK VALVE

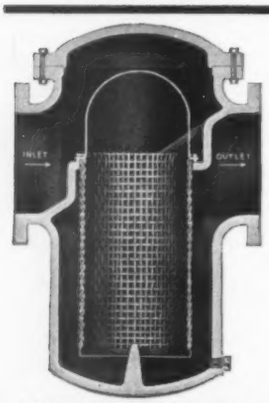
● Cushioned Swing Check valve is non-slam due to perfect cushioning chamber. Minimum friction loss through valve and soon pays in power cost savings.

Furnished in all sizes 4" and larger for all service conditions and pressures. Easily equipped with lever for manual control.

FLOAT VALVE

● Float Control Valve for high or low pressure service which can function on any desired water level variation desired. No water hammer or shock due to air and water cushioning.

Furnished in angle or globe patterns ½" to 24" sizes in bronze, iron body or steel. No metal contacts assure lifetime service.



WATER STRAINER

● Clean water constantly assured by the efficient and economical strainer, supplied with any mesh basket of any material to meet the service demands. Easily and quickly cleaned. Designed for maximum capacities with minimum friction loss. Sizes 3" to 24".

GOLDEN-ANDERSON VALVE SPEC. CO.
1329 FULTON BLDG.
PITTSBURGH PENNA.

CATALOGS AND LITERATURE RECEIVED:

[Any of the publications reviewed in this section can be secured from or through Water Works and Sewerage, if such be desirable.]

KOPPERS' Products:—An impressive and revealing reference booklet has been issued by Koppers of Pittsburgh to show the many and diversified materials, apparatus, equipment and processes marketed by the parent company through its 32 Divisions and Associate Companies. The index from A to Z covers 177 items. Of interest to the water works and sewerage field are such as Ammonium Sulphate, Boilers, Coal, Conveying Systems, Garbage and Rubbish Burning Plants (Complete and Power Producing), Gas Holders, Fire Hydrants, Bituminous Coatings and Paints (Aluminum et al.), Pipe, Sand, Shear and Sluice Gates, Tanks, Valves (Air, Gas, Water—large and small), Welding Equipment, Waterproofing and Wood Preserving Materials. Divisions of chief interest: Hiler Engineering and Construction, Pittsburgh, (garbage incinerators); Bartlet Hayward, Baltimore, Md. (gas holders, tanks); Koppers Eng. & Construction, Pittsburgh (conveyors, processes, research, development); Koppers Company, Pittsburgh (aluminum sulphate, bituminous coatings, water proofing, tar-base paints); Western Gas, Ft. Wayne (boilers for waste heat, castings, and specials, high and low pressure gas-holders and purifiers, fire-hydrants, steel, W.I. and C.I. pipe, shear and sluice gates, gate valves, welding equipment). Then comes an extensive listing of sales offices from coast to coast. For this ready and useful Koppers Index and Directory, address Koppers Company, Publicity Department, Pittsburgh, Pa.

"What Is PERCHLORON?":—This is the question answered by Pennsylvania Salt Manufacturing Company in Chapter 1 of its newest and effectively illustrated 36 page booklet "PERCHLORON." The product is a stabilized super-test dry chlorine carrying powder containing 100 per cent cold water soluble hypochlorite. Easy to store, dissolve and apply; assured "available chlorine" content is 70% and better. The perplexing meaning, to many, of "available chlorine," is defined and illustrated. Then comes "Methods of Preparing Perchloron Solutions and Dosage Regulation"; "Emergency and Permanent Feeding Methods"; "The Residual Chlorine Control Test and How to Make It"; 8 pages of "Perchloron in Water Purification Practices and Its Various Applications"; 4 pages of "Perchloron in Sewage Treatment"; 5 pages of "Perchloron in Swimming Pool Sanitation." Then, a listing of the available size packages (cannisters), and sources of available stocks from coast to coast.

To us, this booklet constitutes a highly valuable "handbook" on methods of Hypo-Chlorination (permanent or emergency) which will enjoy wide distribution and usage—and, like the product, prove especially valuable to works managers and public health engineers for use in emergencies. For a copy of "PERCHLORON" address Pennsylvania Salt Manufacturing Co. (Technical Service), Widener Building, Philadelphia, Pa.

"Pump and Hydraulics Handbook"—From Economy Pumping Machinery Co., Chicago pump manufacturers, has come a worthy pocket size handbook which this company is offering gratis. The first part, devoted

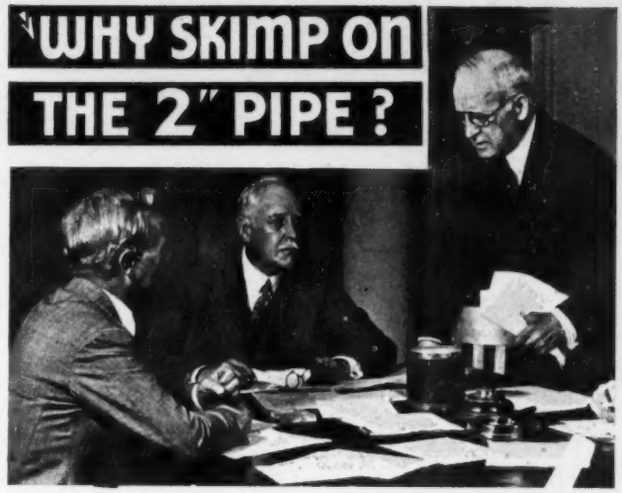
to "Pump Data" serves as a catalog of pumping equipment and pump data. It answers, in a simplified manner, such important questions as "What kind of pump is required?"; "What horsepower is needed to drive it?"; "How to specify and order the proper equipment"; "What cost?—pump, motor and control equipment." The second part is devoted to "Engineering Data" including hydraulics tables, formulae, methods of solving pumping and piping problems. Also, electrical data, pipe and fittings data, and a miscellany of useful references and material for water works and sewerage designers and operators. The thumb index and "use index" makes the handbook easy to use. Two years in preparation, the information contained is based on 25 years of Economy's experience in the pump and hydraulics field. It's well worth a place amongst handbooks. Request "Pump and Engineering Data." Address, Economy Pumping Machinery Co. (Dept. W. & S.), 3431 West 48th Place, Chicago, Ill.

"Modern Variable Speed Control"—A folder from Reeves Pulley Company of Columbus, Indiana, describes and pictures the several and varied applications of Reeves' speed control units adapted to operation in typical modern sewage treatment works. Reeves' three major units, "Vari-Speed Transmissions," "Vari-Speed Motor Pulleys" and "Vari-Speed Motodrives," are all illustrated in actual use. These units and what they are designed to accomplish are described. For a copy of "Modern Speed Control" address Reeves Pulley Company, Columbus, Indiana.

Sewer Pipe Manual for Engineers:—The Robinson Clay Products Company of Akron, Ohio, New York and Canada jointly with Eastern Clay Goods Company (Boston) and N. A. Williams Company (Chicago) have issued a new bulletin to serve as an "Engineer's Manual" of Robinson Vitrified Clay Sewer Pipe, Sprinkling Filter Underdrains, Clay Liner Plates and Sequent Blocks. The manual sets forth proper and improper methods of laying sewer pipe; laboratory and field methods of checking strength of pipe; approved laying and back-filling specifications, showing graphically allowable back-fill burden for various soils; man-hole construction. Useful tables of computing data, dimensions of pipe and fittings, strength charts comparing A.S.T.M. requirements with Robinson products are incorporated. The new "Flexlock" leak and root proof flexible joint ring is described and illustrated. A companion publication is the "Eighteenth Anniversary Catalog of the Robinson Clay Products Companies" (1856-1936) which covers the complete Robinson line of vitrified clay products with price listings. For either or both of these publications, address Robinson Clay Products Company, 2nd National Bank Building, Akron, Ohio, or Empire State Building, New York City.

"Ebony Paint":—Is described in a leaflet bearing this caption, as a metal protecting paint with no oil or asphalt present to volatilize or weather to leave a "chalky" moisture absorbing coating. Being compounded of elastic non-porous gums and chemicals allows the manufacturer to give the long sustained positive guarantee against deterioration of Ebony paint coverings for 5 years. It is resistant to chlorine, sulfur gases, acids and alkalies and is guaranteed against blister, cracking or peeling. In the same leaflet appear startling testimonials as to the service rendered by the coatings of Ebony Paint Manufacturing Company which has 50 years' experience behind their products. For "Ebony Paint" address the company at 2925 East 18th Street, Kansas City, Mo.

WHY SKIMP ON THE 2" PIPE?



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• LONG 18-FT. LENGTHS
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Far-sighted engineers and officials are using cast iron for *all* underground mains. McWane, sensing this trend years ago, was the first to specialize on 2" pipe. First to perfect a Pre-calked Joint. First to ship 18-foot lengths with only *one* intermediate joint. Today, over 25,000,000 ft. serves users from coast to coast.

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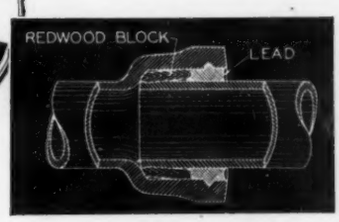

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Here is the simple, self-tightening joint that made McWane 2" standard from coast to coast. The Pre-calked materials are already in the bell.

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CAST IRON PIPE COMPANY
BIRMINGHAM, ALA. SIZES 1¼" THROUGH 12"
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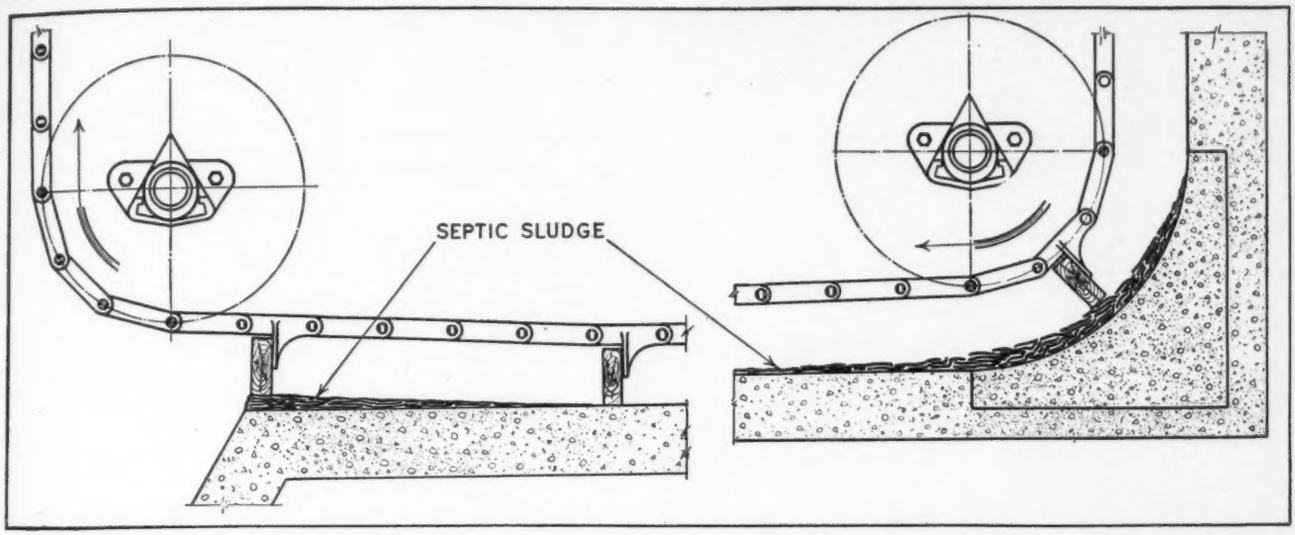
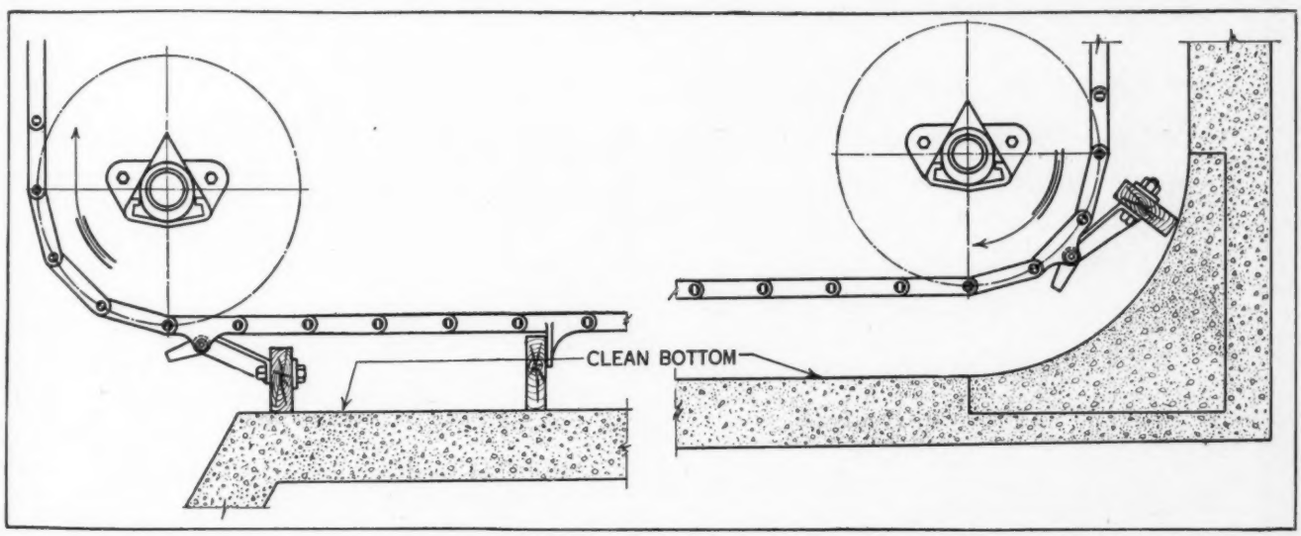
The PIVOTED Flight

A FEATURE OF THE LINK-BELT STRAIGHTLINE COLLECTOR WHICH ASSURES COMPLETE SLUDGE REMOVAL



RIGID FLIGHTS. This drawing shows the sludge left in the settling tank by rigid flights. Clearance, which must be provided under sprocket wheels, increases as flights wear, permitting an accumulation of septic sludge.



PIVOTED FLIGHTS. Link-Belt pivoted flights follow the contour of the tank, assuring positive cleaning of corner turns and floor, regardless of clearances or wear of flights.

Greater efficiency is obtained by the use of pivoted flights because they remove all of the sludge from the bottom of the tank. Only two pivoted flights are required on each collector to clean up. The additional cost of pivoted flights is negligible.

High efficiency, positive results, large capacity and low first-cost, with small maintenance and power expense, are some reasons for the popularity of the Link-Belt Straightline Sludge Collector. Send for Book No. 1542. Link-Belt Company, Philadelphia, Chicago, Los Angeles, Atlanta, or Toronto.

LINK-BELT

3982

STRAIGHTLINE SLUDGE COLLECTORS

SIGNS OF PROGRESS

Adv'g Volume Increase | Circulation Increase

Comparison of A. B. C. Statements

	June 30 1936	Dec. 31 1936	Gain in %
Mail Subscriptions—Individual	3,285	3,459	5%
Total Net Paid, excluding Bulk	3,348	3,577	6%
Total Distribution	4,833	5,133	6%
Superintendents of Water Works, Sewerage, or Both	1,200	1,359	13%
City Engineers, Commissioners and Other Officials Concerned with Water, Sewerage or Both	192	250	30%
Superintendents, Engineers and Chemists in Charge of Treatment Plants	175	183	5%
Consulting Engineers	211	271	28%
Sanitary Engineers	326	326	—
	Jan.-Feb. 1936	Jan.-Feb. 1937	% Increase
Advertising Volume	46 pages	62 pages	34%

Water Works and Sewerage

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FOR BELL AND SPIGOT SEWER PIPE

It's a wise man who uses SERVICISED Pipe Jointing Compound for SERVICISED produces a joint that is tight, flexible, economical, absolutely waterproof, impervious to weather or soil conditions and prevents root growth or other infiltration problems.

Simple to heat and apply, SERVICISED Compound can be applied by ordinary laborers. Further information on request.

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Waterproofings
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For Sewer Tunnels

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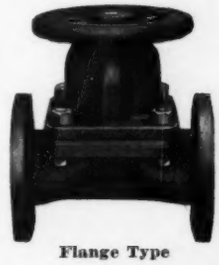
A Valve that stays New!

NEVER TAKEN OUT OF LINE ONCE INSTALLED

Screw Type



Flange Type

Hills-McCanna Saunders' Patent Valves stay new because the diaphragm employed as the opening and closing medium is replaceable. That is the only repair necessary and is accomplished quickly and economically without removing the valve from the line.

The diaphragm also protects the working parts from liquid contact, obviating the necessity of, or dependence upon accurately fitted parts for a perfect closure.

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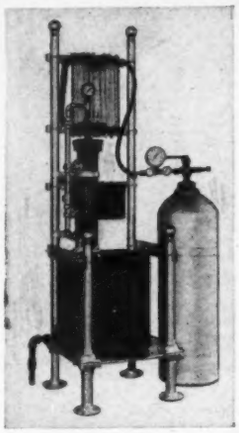

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No Moving Parts

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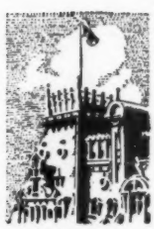

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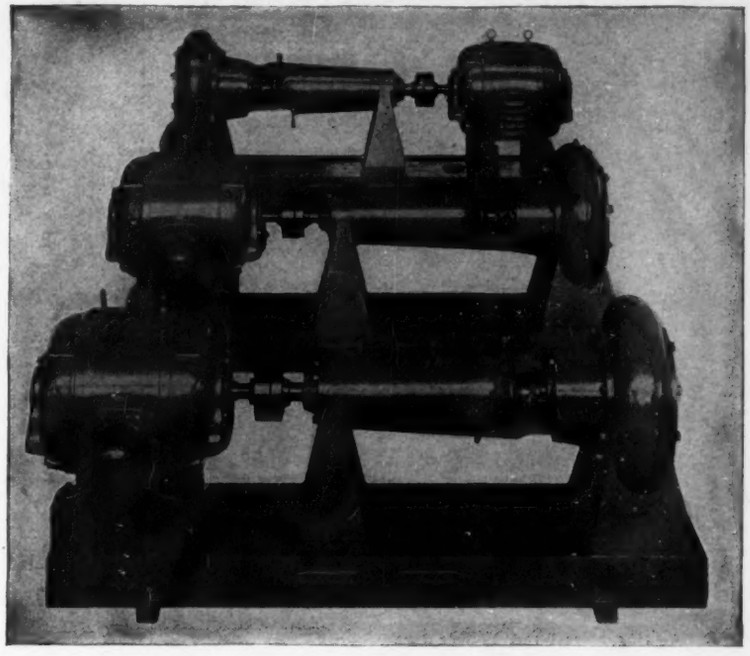

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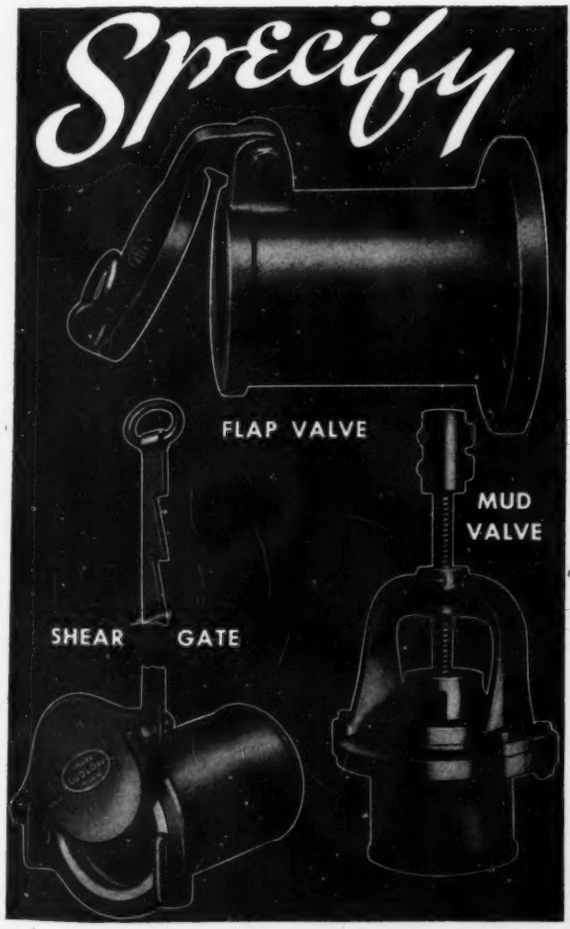

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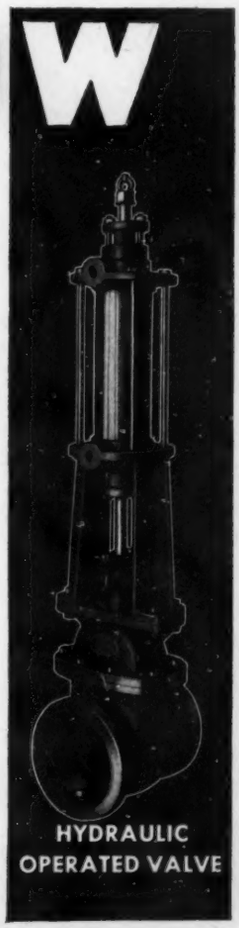

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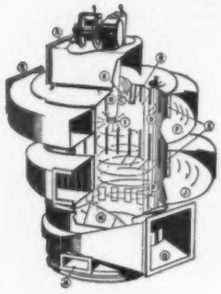

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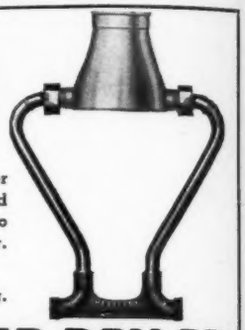

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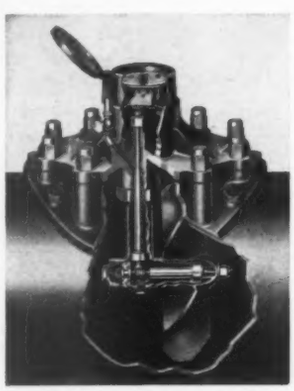
SETTING AND TESTING EQUIPMENT FOR WATER METERS

70,000,000 GALLONS IS A LOT OF WATER



Yet measuring that quantity is merely a day's task for a sixty-inch SPARLING Main-Line Meter. And it's built to stay on the job year after year with little attention or expense. Accurate, easily installed, economical.

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(FERROUS SULPHATE)

... FOR WATER & SEWAGE TREATMENT

(The Base For Chlorinated Copperas)

We invite your inquiries

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RAIN, SNOW, FLOODS don't matter at all!

Caught unprotected in rain, snow or flood, some jointing compounds are *through* • MINERALEAD, in ingot form, is impervious to wet • Stocks of MINERALEAD, submerged for days, were not affected in the least • When flood recession permitted work to be resumed, MINERALEAD was ready and waiting • This better jointing compound has many other advantages you also like. For information, write the ATLAS MINERAL PRODUCTS Company of Penn., Mertztown, Pa.

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For Jointing BELL and SPIGOT MAIN

THE NATIONAL METHOD OF WATER MAIN CLEANING

30 YEARS Experience

WRITE FOR BOOKLET "The cleaning of water mains"

NATIONAL WATER MAIN CLEANING CO.
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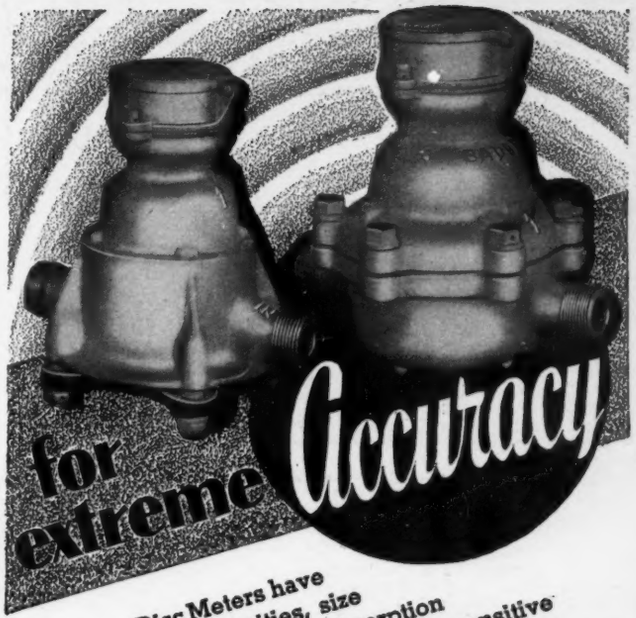

Badger Disc Meters have the largest capacities, size for size, with the least absorption of pressure. They are especially sensitive and accurate from the smallest trickle to the maximum capacity flow. Write for bulletin.
BADGER METER MFG. CO., Milwaukee, Wisconsin

BADGER Water METERS

Water Control Equipment

You will be interested in the complete line offered by MUELLER. Write for catalogs of the equipment in which you are interested.

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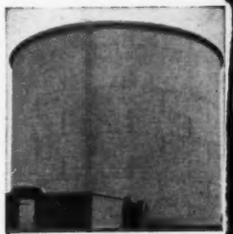

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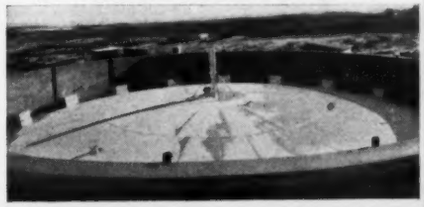

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On other pages in this issue you will find described new and improved equipment, etc., as well as reviews of recent trade literature received by us. By requesting the literature described you will be able to keep your catalog file complete and up to date.

To our readers desiring additional help or information we will be glad to assist you in securing more complete information or data on any equipment or product you need. Use the convenient blank below—no cost or obligation.

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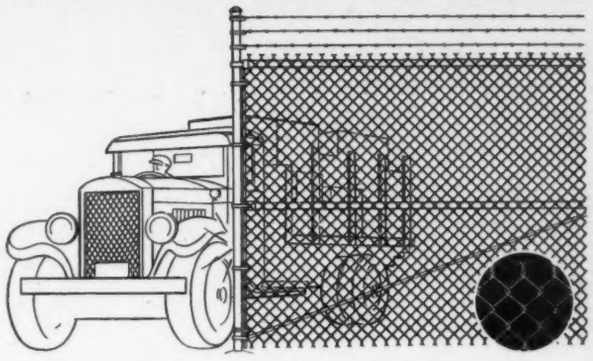

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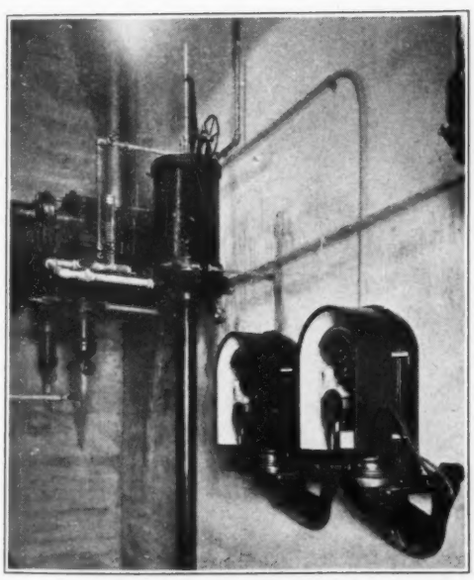

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The Dash (—) Denotes Current Advertisers Who Do Not Appear in This Issue.

A

Activated Alum Corp. 71
Albright & Friel, Inc. 68
Alvord, Burdick & Howson. 68
American Brass Co., The. —
American Cast Iron Pipe Co. 16
*American Gas Products Corp. 14
American Hammered Piston Ring Div. of Koppers Co. 17
American Radiator Co. 7
Anaconda Copper & Brass. —
Armco Culvert Mfgrs. Asso. 9
Arrowhead Iron Works. 76
Atlas Mineral Products Co. of Pa., The. 75

B

Badger Meter Mfg. Co. 75
Barrett Company, The. 61
Barstow & Le Feber, Inc. 68
Bartlett Hayward Div. of Koppers Co. 17
Bellevue-Stratford Hotel. 72
Black & Veatch. 68
Bowen Research Corporation. 74
Builders Iron Foundry. 18
Burns & McDonnell Engr. Co. 68

C

*Carborundum Company, The. 13
Cast Iron Pipe Research Assoc., The. 22
Chain Belt Company. 10
Chester Engrs., The. 68
*Chicago Bridge & Iron Co. 3
Chicago Pump Company. —
Chicago Rawhide Mfg. Co. —
Clark Controller Co., The. 20
Columbia Alkali Corp., The. —
Columbian Iron Works. 75
Cooper-Bessemer Corp. —
Corning Glass Works. —
Crane Co. 15

D

*Dorr Company, Inc., The. Third Cover
Dresser Mfg. Company, S. R. 63

E

*Economy Pumping Mach. Co. —
*Edson Corporation, The. 76
Electro Bleaching Gas Co. —
Engineering & Construction Div. of Koppers Co. 17
Everson Mfg. Co. 72

F

Faesy & Besthoff, Inc. 74
*Filtration Equipment Corp. —
Ford Meter Box Co. 74
Fuller & McClintock. 68
*Fuller Company. —

G

Gascoigne & Associates. 68
*Golden-Anderson Valve Specialty Co. 66
Graver Tank & Mfg. Co., Inc. 75
Great Western Electro-Chemical Co. —
Greeley & Hansen. 68
*Gruendler Crusher & Pulverizer Co. 74

H

Hellige, Inc. —
Hiler Engr. & Const. Co. 17
Hill Associates, Nicholas S. 68
Hills-McCanna Co. 71
Hudson Coal Co., The. —

I

*Industrial Chemical Sales. 5
*Inertol Company, Inc. 72
*International Filter Co. 16

K

Knowles, Inc., Morris. 68
Koppers Coal Co. 17
Koppers Company. 17

L

La Motte Chemical Products Co. 76
Layne & Bowler, Inc. 77
Limestone Products Corp. —
Link Belt Co. 69
Lock Joint Pipe Co. 75
Ludlow Valve Mfg. Co., The. 73
Lynchburg Foundry Company. 14

M

Maryland Drydock Co. —
Master Builders Co., The. 11
Mathieson Alkali Works, Inc., The. 12
McWane Cast Iron Pipe Co. 67
Metcalf & Eddy. 68
Modern Iron Works. 72
Monsanto Chemical Company. —
Mueller Co. 75

N

*National Water Main Cleaning Co. 75
Nichols Engineering Research Corp. —
Norton Company. —
Nussbaumer & Clarke, Inc. 68

P

Pacific Flush Tank Co. —
*Pennsylvania Salt Mfg. Co. 6
*Permutit Company, The. 16
*Phipps & Bird, Inc. —
Pirnie, Malcolm. 68
*Pittsburgh Des Moines Steel Co. 19
Pittsburgh-Equitable Meter Co. Front Cover
Pittsburgh Steel Co. 77
Portland Cement Asso. 4
Potter, Alexander. 68
Proportioneers, Inc. 64

R

Reeves Pulley Company. 18
Reilly Tar & Chemical Corp. —
Riddick, Thomas M. 68
Roberts Filter Mfg. Co. 74
Royer Foundry & Machine Co. —
Russell & Axon. 68

S

*Servicised Products Corp. 71
*Simplex Valve & Meter Co. 77
South Bend Foundry Co. 76
Sparling, R. W. 74

T

Tar & Chemical Div. of Koppers Co. 17
*Taylor & Co., Inc., W. A. —

U

*United States Pipe & Foundry Co. Second Cover

V

Victor Equipment Company. 73
*Vogt Mfg. Co., Inc. 72

W

*Wallace & Tiernan Co. Back Cover
Water Leak Detector Co. —
Western Gas Div. of Koppers Co. 17
White Tar Co. of N. J., Inc. 17
Whitman & Howard. 68
*Wood Co., R. D. —
Wood Preserving Corp. 17
Worthington Pump & Mach. Corp. 65

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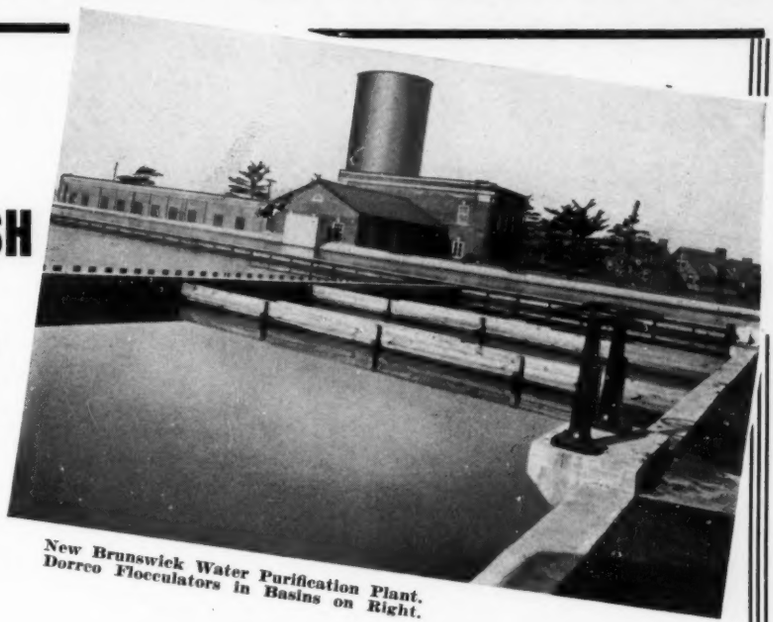

New Brunswick Water Purification Plant. Dorrco Flocculators in Basins on Right.

A battery of Dorrco Flocculators was installed in the influent end of one of the sedimentation basins. As a result alum and lime consumption has been reduced, a better water is being sent to the filters and overall plant performance has been generally improved.

Dorrco Flocculators are now in use, or on order, at 92 municipalities and industrial concerns. The individual capacities of these installations range up to 200 M.G.D. The Dorrco Flocculator is about the only unit in water treatment practice that pays for itself out of chemical and other savings.

Write for our bulletin on "Flocculation and Mixing"

DORRCO

NEW BRUNSWICK OPERATING DATA*

	Before Installation Dorrco Flocculators	After Installation Dorrco Flocculators
Average Flow — M.G.D.	5.8	6.5
Turbidity — P.P.M.	13	14
Color — P.P.M.	54	46
Alkalinity — P.P.M.	3.72	3.90
Alum Consumption — lbs./M.G.	147	107
Alum Saving — per cent	—	27.2
Alum Saving — per yr.	—	47.3 tons
Lime Consumption — lbs./M.G.	125	111
Lime Saving — per cent	—	11.2
Lime Saving — per yr.	—	16.5 tons
Wash Water — M.G. per yr.	46.5	39.7
Wash Water Saving — per M.G. — per cent	—	27.2

*Courtesy Mr. Asher Atkinson, City Engineer, New Brunswick, N. J.

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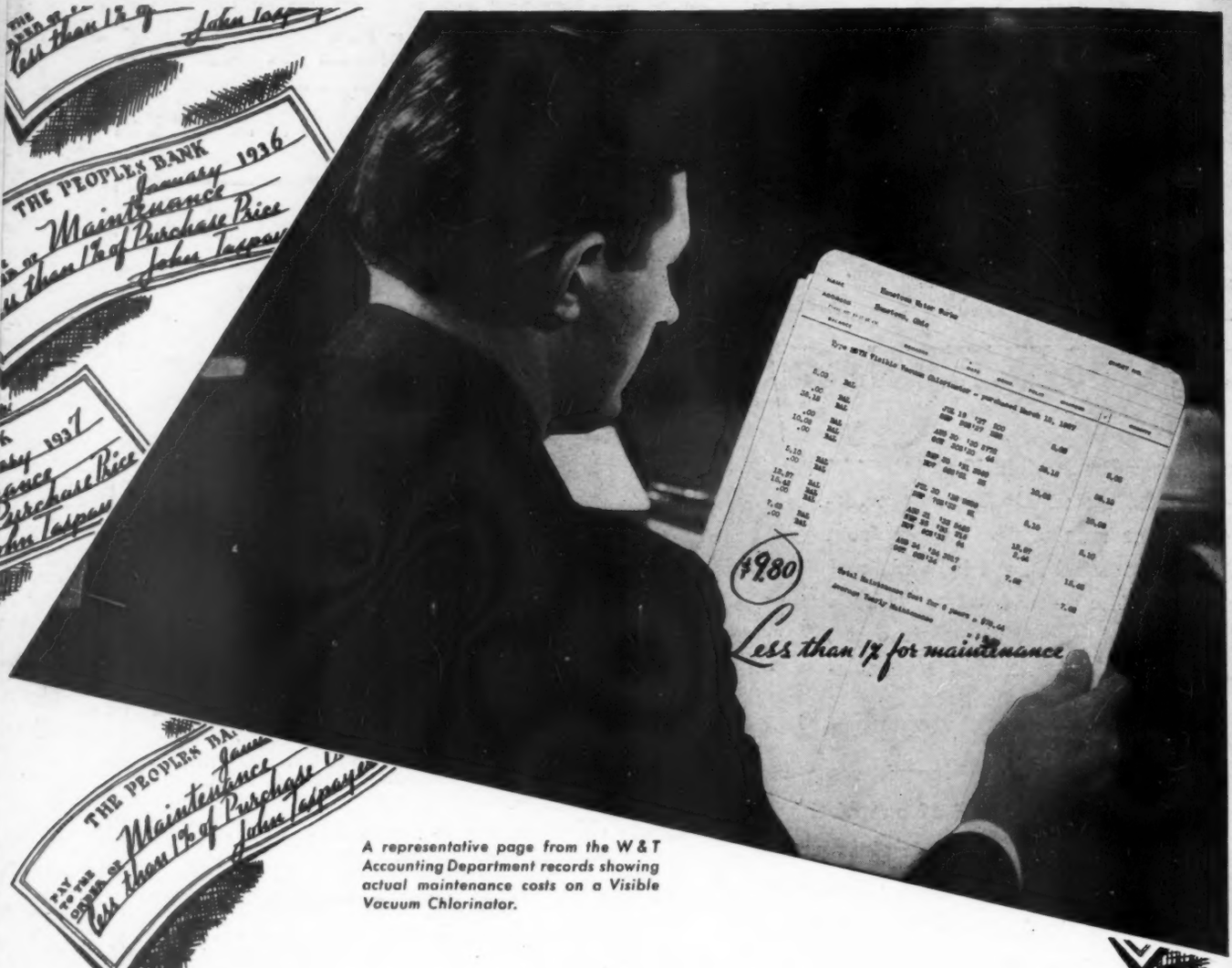
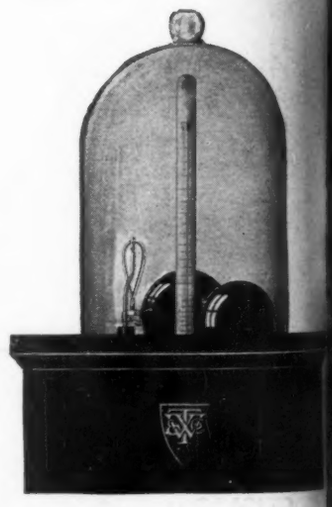
SAVING TOMORROW'S TAX DOLLAR



A representative page from the W & T Accounting Department records showing actual maintenance costs on a Visible Vacuum Chlorinator.

THE CHLORINATION DOLLAR MUST BUY.. MAINTENANCE ECONOMY



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Technical publications 38, 157 and 158 describe W & T Visible Vacuum Chlorinators. Ask for your copies.

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